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RESEARCH TRIANGLE INSTITUTE
Durham, North Carolina

FINAL REPORT: PART II

R-OU-81

Analysis of Survey Data

E. L. Hill, W. K. Grogan,
R. O. Lyday and H. G. Norment

15 February 1964

Prepared for
Office of Civil Defense
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OCD Sub-task 1115A
RTI Project OU-81

by

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ABSTRACT FOR PART II

This part contains sixteen appendices (A-P) to the chapters of Part I of the final report for OCD Sub-task 1115A, Analysis of Survey Data. These appendices contain details of computer programs used in categorization of structures with respect to technical shielding characteristics and resultant tabulations (A-E); details of the RTI 33 NFSS Phase 1 building sample selection method (F); an illustration of procedures used in identifying building elements critical to PF computations (G); RTI computational method and forms used in making Engineering Manual PF calculations for the 33 sample buildings (H); descriptions of the 33 buildings, the five PF results (AE Phases 1 and 2, RTI FOSDIC with and without partitions, and Engineering Manual), and analyses of individual building input and procedural differences judged to have affected the PF differences (I); construction details of four buildings used in comparing experimental and calculated PF's (J); trapped potable water field data gathered in the 33 building survey (K); detailed analyses of Technical Operations Research reports that affect the procedures used to calculate PF's (L-N); a summary of conclusions and recommendations made by Technical Operations Research and concurred with by RTI (O); and detailed recommended modifications to the NBS-NFSS Computer Program (P).

PART II CONTENTS

PART II CONTENTS (continued)

PART II CONTENTS (continued)

Analysis of Survey Data: Part II - Appendices

INTRODUCTION

This part contains appendices which provide supplemental detailed information regarding subjects discussed in Part I of the final report for Office of Civil Defense Sub-task 1115A, Analysis of Survey Data. They are reported to substantiate conclusions and recommendations made in Part I and because of their potential value to other research projects.

Sub-task 1115A involved four major areas of study: (1) analysis of the NFSS findings to determine probable error; (2) categorization of surveyed structures with respect to technical shielding characteristics; (3) evaluation of new information on shielding; and (4) recommendations for changes to the NBS-NFSS Computer Program.

Brief summaries of the appendices are contained in the following paragraphs:

Appendices A-D

Details of computer programs used in the selection of a sample of 1541 NFSS Phase 1 buildings for categorization (see Part I, Chapter 3) and for the compilation of shelter and building statistics are contained in these appendices. These programs are in FORTRAN for use on the National Bureau of Standards IBM 7090 Computer. Source program listings are included for each of the computer programs. The detailed structural input data and PF output data for the sample are available on magnetic tape for any additional categorization which may become desirable.

Appendix E

Tabulations are presented for NFSS Phase 1 buildings and shelter areas categorized by story number, percent apertures, contaminated plane width, floor area, interior partitions, wall mass thickness, dose source, percent basement

exposure, and physical vulnerability. These statistics are presented for buildings and shelter areas by building PF class. A PF Class 3 building is defined as having its highest rated shelter in PF Category 3.

Summaries of the tabulations are: (1) 39 percent of the shelter areas are in the basement, (2) the mean story number varies from three to four for all PF categories except Category 8, where it jumps to six, (3) the average percent of apertures for all buildings ranges from fifteen to nineteen percent and for shelter areas never exceeds 25 percent, (4) the vast majority of the shelter areas, 78 percent, have an area in the range of 1,000 - 10,000 square feet, (5) only seventeen percent of the total shelter areas have interior partitions reported, (6) the modal value of the exterior wall mass thickness falls in the range of 100 - 150 psf, and (7) eighty percent of the sample buildings have only one part reported, 12 percent have two parts and four percent have three parts.

A thorough discussion of categorization of technical shielding characteristics of NFSS structures is presented in Part I, Chapter 3.

Appendix F

Details of the selection of 33 sample buildings surveyed by RTI (see Part I, Chapter 4) to estimate the probable error of the NFSS findings are presented in this appendix. Included are descriptions of the universe of buildings sampled, the development of sampling units, procedures used in determining the specific buildings, and an estimate of the statistical confidence of observed average differences. Comparisons are made in Appendix I.

Appendix G

A sensitivity analysis used to identify building structural elements which are most important in radiation shielding is discussed. Studies of this type

helped to identify structural data requiring more precision in evaluation in the RTI survey described in Part I, Chapter 4, and Appendix I.

Appendix H

This appendix describes the standardized computational procedures developed and used by RTI to calculate protection factors by the Engineering Manual (EM) method for the sample of 33 buildings analyzed in Part I, Chapter 4. and Appendix I. Included are functional equations used in the computations; samples of forms used to determine contributions from the adjacent wall, through the ceiling, and through the floor; a sample of the form used for basement shelters; and detailed instructions for using the forms. These procedures should be of use to those required to carry out EM computations routinely.

Appendix I

Presented are detailed descriptions of the 33 sample buildings surveyed by RTI and reported in Part I, Chapter 4. AE Phase 1 and RTI FOSDIC input data are compared for each building. Also reported are: (1) plan view building outlines, (2) photographs of each building, (3) results of PF computations, (4) an analysis of the input and procedural differences judged to have influenced the difference in AE Phase 1 and RTI calculated PF's, and (5) a description of the formulas used in the statistical analyses.

Appendix J

Construction details necessary to calculate Engineering Manual PF's for four buildings are presented in Appendix J. These buildings were previously experimentally evaluated by Edgerton, Germeshausen, and Grier, Inc., (EG&G). Experimental PF's and EM computations are compared for these four buildings in Part I, Chapter 5. The results are close enough in most cases that modest mass thicknesses assigned to interior contents would make them agree.

Appendix K

Sources and amounts of potable water available in each of the buildings in the RTI 33 building sample are contained herein. A summary of the potable water survey results is contained in Part I, Chapter 8. An average of 2.96 gallons per PF Category 4-8 shelter space was found in the 33 building sample.

Appendices L, M, and N

Appendices L, M, and N contain RTI's detailed analyses of Technical Operations Research (Tech Ops) Reports TO-B 62-26, TO-B 62-58, and TO-B 63-6, respectively. The first two report experimental measurements of the effect of limited strips of contamination on a model building and the third report is concerned with model experiments on interior partitions. The effect of these reported results and others on the calculation of building protection factors is summarized in Part I, Chapter 6.

Appendix O

This is a consolidation of conclusions and recommendations made by Tech Ops in reports reviewed by RTI and concurred with by RTI. A review of all shielding research reports evaluated by RTI is presented in Part I, Chapter 6.

Appendix P

Details of recommendations made by RTI in Part I, Chapter 7, for changes in the NBS-NFSS Computer Program are presented in this appendix. The recommendations for changes bring the computer method of calculating PF's closer to the Engineering Manual method while using only NFSS Phases 1 and 2 data. Recommendations for changes in the method of calculating contributions are made for exposed basements, roofs, stories above grade, and areaways. Revised area factors and a method for considering the effect of interior partitions are also included.

Appendix A

Program Operating Instructions for Categorization Building Sample Selection

I. INTRODUCTION

Appendices A, B, C, and D give the listings and describe the computer programs that select a stratified sample of NFSS buildings and categorizes them by structural characteristics. The results of the statistical analysis of the structural characteristics of the 1541 building sample are presented in tabular form in Appendix E. Chapter 3 summarizes these results and describes the use of the computer programs. The data in Appendices A-E and Chapter 3 were originally submitted to OCD as Research Memorandum RM 81-9 (Reference 1).

Altogether, there are four separate IBM 7090 FORTRAN programs which are used for the selection and analysis of the buildings. Appendix A contains the operating instructions for each program and presents some additional descriptive material for the various calculations. Appendices B and C, respectively, contain the Primary Source Program listings that are used for the sample selection and statistical study programs. Formulas used at several stages of the calculations were developed as subroutines. Appendix D lists and describes these subroutine source programs.

The sample selection calculations are done in two steps using programs BSSM2 and BSSM1 involving independent computer runs. Program BSSM2 selects the sample from the M2 (shelter) file, and program BSSM1 merges with this the corresponding M1 (FOSDIC) file data and prepares a binary sample tape which contains all of the M2 and M1 file data for each building in the sample.

Program BSPO, which also involves an independent computer run, prepares BCD tapes for off-line printing which contain the M2 and M1 data for the complete sample.

Program SHSTAT segregates the sample data according to building PF class (see Part I, Chapter 3, Section IV. A. 1) and prepares numerical tabulations relating PF with structural characteristics for each building class and for the total sample population. Optionally, the complete M2 and M1 data, segregated in building PF classes, may be output. Program SHSTAT, with or without the optional output, involves one computer run.

Operating instructions and additional descriptive material are presented in the following sections for each calculation. Complete source program listings are given in Appendices B, C, and D for all programs used. The programs were written for use on the IBM 7090 computer under control of the Bell SYS 3 operating system.

II. PROGRAM BSSM2

A. Card Input

1. Selection interval and number of M2 file tapes to be read are inputs. FORMAT (2I10).
2. One card is used for each M2 file tape, in the order that the tapes are read. Each card contains the number of shelter files on a tape. FORMAT (I10).

B. Tape Input

Tapes B5, B6, B7, and B8 are used for the four M2 file tapes, in order of reading*. If the tapes are mounted out of proper sequence, the program will write a comment to this effect on the system output tape; it will examine the remaining tapes to ascertain their sequence, write this on the system output tape, and then terminate the job.

* NBS tapes 1055, 1085, 1527, and 1349 were used for this study.

C. Binary Tape Output

Shelter file entries for the sample buildings are written on tape A5. This tape is used for input to Program BSSM1.

D. BCD Output

During the course of the calculations, various tests are made on the consistency and accuracy of the data, and tests also are made for tape checks and end-of-files. When these tests are failed, appropriate comments are made on the system output tape and the job is terminated.

A subtotal of the number of shelter file records read is printed after reading completely each M2 file tape. The number of buildings rejected on each tape also is printed. Upon successful completion of the job, the random number used to start the building selection and the number of buildings selected for the sample are printed. In addition, the numbers of buildings and shelters scanned are printed in octal form.

E. Running time was 33 minutes for the 1541 building sample.

III. PROGRAM BSSM1

A. Card Input

Number of buildings in sample, and number of M1 file tapes to be read are inputs. FORMAT (2I10).

B. Tape Input

The intermediate sample tape generated by program BSSM2 is mounted on A5.

The M1 file consists of nine reels of tape*. The first three, in order of reading, are mounted on B5, B6, and B7. When B5 has been completely read, it is rewound and the program automatically begins reading B6. The tape on B5 should be replaced with the fourth M1 file reel, etc. After B7 is completely read, the program stops. When the start button is pushed, the reading cycle automatically begins again at B5. This process continues until FOSDIC schedules have been found for all building parts in the sample.

C. Binary Tape Output

The program merges the M2 and M1 file data for the sample buildings and writes these data in binary form on tape A6. This tape, designated as the sample tape, provides input for subsequent stages of the study.

D. BCD Output

Information sufficient to identify completely each FOSDIC schedule for the sample buildings is written on the system output tape. One line of information, as described in Chapter 3, Section III. B. Step 2, is printed for each FOSDIC schedule.

During the calculations various accuracy and consistency tests are made on the data. In addition, tape check and end-of-file tests are made. If these tests are failed, an appropriate comment is written on the system output tape and the job is terminated. However, note that pauses occur each time the reading of tape B7 has been completed and also when a FOSDIC count obtained from the M1 file tapes does not agree with the tally made by the program. To continue, pu^ ᴊTART.

---

* The tapes used for this study were NBS tapes 1043, 1045, 1047, 1049, 1525, 1024, 1539, 1540, and 1541.

When the job is successfully completed, the total number of FOSDIC schedules selected is written in octal form on the system output tape. Also, the total numbers of sample shelters in each of the nine PF categories from 0 through 8 are listed on the system output tape.

E. Running time was 65 minutes for the sample of 1541 buildings.

IV. PROGRAM BSPO

A. Card Input

Number of buildings in the sample is input. FORMAT (I10)

B. Tape Input

The binary sample tape generated by program BSSM1 is mounted on A6.

C. BCD Output

Tape B5 is used for BCD output of the FOSDIC schedule data for the number of buildings specified by the card input. This output is illustrated in Figure 3 of Chapter 3*. For the 1541 building sample, 3½ reels of tape were written.

Tape B6 is used for BCD output of the PF calculation results for the shelters of as many buildings as are specified by the card input**. This output is illustrated in Figure 4*. Approximately 2/3 reel of tape was written for the 1541 building sample.

D. Running time was approximately 22 minutes for the 1541 building sample.

V. PROGRAM SHSTAT

A. Card Input

The number of buildings in the sample and a quantity KPTO are input on cards. FORMAT (2I10). See Section C below for a description of KPTO.

* All referenced figures are in Chapter 3.

**A check of the printouts for a subsample against the printouts for the same shelter spaces on file in the Pentagon, showed frequent errors in the shelter volume as given in the subsample printout. At the time of this writing, no errors to account for this have been found in the programs presented in this report. Accordingly, it is assumed that either some adulteration of the story height values on the M2 file tapes has occurred, or that the disposition of the story height data in the shelter file entries has been incorrectly reported in Reference 2.

B. Tape Input

The binary sample tape generated by Program BSSM1 is mounted on A5. It must be file protected. Tapes A6, B5, and B6 are used for intermediate storage. After the sample tape, on A5, has been read and rewound, replace it with a pool tape for intermediate storage use.

C. BCD Output

1. If KPTO = 0, complete FOSDIC and shelter PF data are written on the system output tape for each building PF class. See Figures 3 and 4 for illustrations of this output. If KPTO ≠ 0, this output is deleted.

2. Statistical tabulations for each shelter characteristic listed in Chapter 3, Section IV. A. 2, with the exception of percent basement exposure, are output for each building PF class.

3. Statistical tabulations consisting of accumulated shelter statistics for all building PF classes are output for each characteristic listed in Chapter 3, Section IV. A. 2.

4. Statistical tabulations are output for each building characteristic listed in Chapter 3, Section IV. B. 2.

D. Running time was approximately 10 minutes for the 1541 building sample for the case with FOSDIC and shelter PF output deleted. When the complete output was obtained, the running time was approximately 31 minutes.

REFERENCES

1. H. G. Norment. A Statistical Analysis of the Influence of Building Characteristics on Fallout Radiation Shielding. Research Memorandum RM 81-9. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 6 September 1963.

2. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for the National Fallout Shelter Survey. NBS Report 7539. Washington: U. S. Department of Commerce, July 1962.

Appendix B

Source Program Listings for Sample Selection

I. INTRODUCTION

This appendix gives a brief description of computer programs used only for selecting the 1541 sample buildings used in categorization (see Chapter 3). Source program listings are included. Subroutines used in the sample selection calculation but not listed herein are discussed in Appendix D.

II. PROGRAM DESCRIPTIONS

A. BSSM2

See Part I, Chapter 3, Section III. B. Step 1 and Appendix A, Section II.

B. BSSM1

See Part I, Chapter 3, Section III. B. Step 2 and Appendix A, Section III.

C. BSPO

See Part I, Chapter 3, Section III. B. Step 3 and Appendix A, Section IV.

D. RNDM

See Part I, Chapter 3, Section III. B. Step 1a.

E. FTPRD

This program reads the eight word BCD prefix record of each M2 file tape.

F. FTSR (NT, W, NW, NFG)

A record of NW binary words from tape NT is read into core storage starting with location W. If a tape check is encountered five successive times, NFG = 1. If an end-of-file is encountered, NFG = 2. Otherwise NFG = 0. NFG is a FORTRAN integer.

G. FPTNO (W1, W2, N)

This program extracts the building part number from words W1 and W2 and stores it in the decrement of N.

H. FSKPD

This program skips over the twelve word BCD record prefix to the M1 file tapes.

I. F2FLD (NT, NFD, NFG)

This program reads the final record on each M1 file tape (NT). This record contains the number of FOSDIC schedules on the tape. This is stored in the decrement of NFD. See description of NFG under FTSR above.

III. SOURCE PROGRAM LISTINGS

```
C     BUILDING SAMPLE SELECTOR FROM NBS MASTER 2 TAPES (SHELTER FILE)    BSSM2
C                      RESEARCH TRIANGLE INSTITUTE                        BSSM2
C                                                                         BSSM2
      DIMENSION PW(8),NRF(20),WO(2401),W1(3),W2(3),W3(3),W4(1000,8)       BSSM2
     1,WQ(2401)
      NBDW=0                                                              BSSM2
      NT=14                                                               BSSM2
      NR=0                                                                BSSM2
      NS=0                                                                BSSM2
      NBLD=0                                                              BSSM2
      DO 10 KK=1,3                                                        BSSM2
   10 W1(KK)=0.                                                           BSSM2
      LT=5                                                                BSSM2
      I1=0                                                                BSSM2
      NTR=0                                                               BSSM2
      N2BLD=0                                                             BSSM2
      LR=1                                                                BSSM2
      LL=0                                                                BSSM2
      NP2=18                                                              BSSM2
      NW=2401                                                             BSSM2
      NSAM=0                                                              BSSM2
      READ 5010,N3,N4                                                     BSSM2
      DO 50 JJ=1,N4                                                       BSSM2
   50 READ 5040,NRF(JJ)                                                   BSSM2
      Z=N3                                                                BSSM2
      Y=RNDMF(Z)                                                          BSSM2
      N2=Y                                                                BSSM2
      Z=N2                                                                BSSM2
      IF(Y-Z)90,90,60                                                     BSSM2
   60 N2=N2+1                                                             BSSM2
   90 CALL FSHFT(N2,2N2,LR,NP2)                                           BSSM
      DO 270 JJJ=1,N4                                                     BS  2
      JJJ=JJJ                                                             BSS 2
      NT=NT+1                                                             BSSM
  100 REWIND NT                                                           BSSM2
  110 CALL FTPRD(NT,NTR,PW(8),NFG)                                        BSSM2
      IF(NFG-1)113,111,112                                                BSSM2
  111 PRINT 5060,NT                                                       BSSM2
      GO TO 120                                                           BSSM2
  112 PRINT 5080,NT                                                       BSSM2
      GO TO 120                                                           BSSM2
  113 IF(NTR-JJJ)120,140,120                                              BSSM2
  120 REWIND NT                                                           BSSM2
      PRINT 5000,NT,NTR                                                   BSSM2
      KK=N4+14-NT                                                         BSSM2
      DO 130 JJ=1,KK                                                      BSSM2
      NT=NT+1                                                             BSSM2
      REWIND NT                                                           BSSM2
      CALL FTPRD(NT,NTR,PW(8),NFG)                                        BSSM2
      REWIND NT                                                           BSSM2
      IF(NFG-1)123,121,122                                                BSSM2
  121 PRINT 5060,NT                                                       BSSM2
      GO TO 130                                                           BSSM2
  122 PRINT 5080,NT                                                       BSSM2
      GO TO 130                                                           BSSM2
```

```
123 PRINT 5000,NT,NTR
130 CONTINUE
    CALL ENDJOB
140 II=NRF(JJJ)
    DO 250 KKK=1,II
    CALL FTSR(NT,WO(2401),NW,NFG)
    DO 1140 JKL=1,2401
    LKJ=2402-JKL
1140 WO(JKL)=WO(LKJ)
    NR=NR+1
    IF(NFG-1)143,141,142
141 PRINT 5070,NT,NR
    REWIND NT
    CALL ENDJOB
142 PRINT 5090,NR,NT
    REWIND NT
    CALL ENDJOB
143 DO 220 LLL=2,2401,8
    LLL=LLL
    CALL FINCR(NS,LR)
    DO 150 I=1,3
    MMM=LLL+I-1
150 W2(I)=WO(MMM)
    CALL FMAS*(W2(3))
    DO 160 I=1,3
    CALL FCOMP(W1(I),W2(I),NCOMP)
    IF(NCOMP)170,160,170
160 CONTINUE
    GO TO 205
170 IF(NBDW)175,175,350
175 DO 180 J=1,3
180 W1(J)=W2(J)
    MM1=LLL+6
    CALL FSHFT(WO(MM1),PF,LL,NP2)
    IF(PF)190,215,200
190 PRINT 5020,NT,NR,MM1
    GO TO 220
200 CALL FINCR( NBLD,LP)
205 CALL FCOMP(ZN2, NBLD,NCOMP)
    IF(NCOMP)210,200,220
210 PRINT 5030,NT,NR,LLL
    CALL ENDJOB
215 NZBLD=NZBLD +1
220 CONTINUE
250 CONTINUE
    REWIND NT
    PRINT 5050,NT,NR,NZBLD
    NZBLD=0
    NR=0
270 CONTINUE
    ENDFILE LT
    REWIND LT
    PRINT 5100,NSAM,NBLD,NS,N2
    CALL END JOB
300 NBDW=1
```

```
      I1=I1+1                                                           BSSM2
      DO 310 I2=1,8                                                     BSSM2
      K11=LLL+I2-1                                                      BSSM2
  310 W4(I1,I2 )=WC(K11)                                                BSSM2
      GO TO 220                                                         BSSM2
  350 WRITE TAPE LT,I1                                                  BSSM2
      DO  360 I3=1,I1                                                   BSSM2
  360 WRITE TAPE LT,(W4(I3,J2),J2=1,8)                                  BSSM2
      NEDW=0                                                            BSSM2
      I1=0                                                              BSSM2
      CALL FINCR(ZN2,N3)                                                BSSM2
      NSAM=NSAM+1                                                       BSSM2
      GO TO 175                                                         BSSM2
 5000 FORMAT(10X,15HTAPE DRIVE NO. I2,3X,23HCONTAINS FILE REEL NO. I2//) BSSM2
 5010 FORMAT(2I10)                                                      BSSM2
 5020 FORMAT(10X,35HA NEGATIVE PF HAS BEEN FOUND, TAPE I2,9H, RECORD I4, BSSM2
     17H, WORD I4///)                                                   BSSM2
 5030 FORMAT(10X,22HNEG NCOMP FOUND, TAPE I2,9H, RECORD I4,7H, WORD I4)  BSSM2
 5040 FORMAT(I10)                                                       BSSM2
 5050 FORMAT(10X,31HTOTAL NO. RECORDS THROUGH TAPE I2,3H ISI10,1H.,5X,I5 BSSM2
     1,34H BUILDINGS WERE REJECTED THIS TAPE///)                        BSSM2
 5060 FORMAT(10X,5HTAPE I2,73HHAS FAILED ON 5 SUCCESSIVE TAPE CHECK TEST BSSM2
     1S WHILE READING FIRST RECORD///)                                  BSSM2
 5070 FORMAT(10X,5HTAPE I2,59H HAS FAILED ON 2 SUCCESSIVE TAPE CHECK TES BSSM2
     1TS WHILE READING I10,9HTH RECORD///)                              BSSM2
 5080 FORMAT(10X,57HAN EOF HAS BEEN FOUND WHILE READING FIRST RECORD OF  BSSM2
     1TAPE I2////)                                                      BSSM2
 5090 FORMAT(10X,42HAN EOF HAS BEEN ENCOUNTERED WHILE READING I10,20HTH  BSSM2
     1RECORD FROM TAPE I2////)                                          BSSM2
 5100 FORMAT(10X,57HTHE TOTAL NUMBER OF BUILDINGS SELECTED FOR THE SAMPL BSSM2
     1E IS I10/10X,16HFROM A TOTAL OF O12,15H BUILDINGS AND O12,9H SHELT BSSM2
     2ERS/10X,30HTHE RANDOM NUMBER GENERATED ISI10///)                  BSSM2
      END                                                               BSSM2
```

```
C     BUILDING SAMPLE SELECTOR FROM [illegible] MASTER 1 TAPES(FOSDIC FILE)       BSSM1
C         H.G. NORMENT                                                   BSSM1
C                                                                        BSSM1
      DIMENSION W(1000,8),MPT(100),M1(3),M2(3),MO(2700),SF(100,45),      BSSM1
     . TIST(9),MPF(9),MD(2700)                                           BSSM1
      NPG=0                                                              BSSM1
      NR=0                                                               BSSM1
      NFOTP=0                                                            BSSM1
      LL=0                                                               BSSM1
      LR=1                                                               BSSM1
      L6=6                                                               BSSM1
      L12=12                                                             BSSM1
      L18=18                                                             BSSM1
      L24=24                                                             BSSM1
      L30=30                                                             BSSM1
      NT=15                                                              BSSM1
      LT=5                                                               BSSM1
      NTO=6                                                              BSSM1
      LTI=0                                                              BSSM1
      NW=2700                                                            BSSM1
      INCR=60                                                            BSSM1
      KFL=0                                                              BSSM1
      NOT=0                                                              BSSM1
      NPTG=0                                                             BSSM1
      NBDC=0                                                             BSSM1
      NPF=0                                                              BSSM1
      DO 50 I=1,9                                                        BSSM1
   50 MPF(I)=0                                                           BSSM1
      READ 5000,NBLD,MTO                                                 BSSM1
      REWIND LT                                                          BSSM1
      REWIND NT                                                          BSSM1
  100 NP=1                                                               BSSM1
      MPT(1)=0                                                           BSSM1
      READ TAPE LT,I1                                                    BSSM1
      DO 190 I2=1,I1                                                     BSSM1
      READ TAPE LT,(W(I2,I3),I3=1,8)                                     BSSM1
      CALL FPTNO(W(I2,3),W(I2,4),NFT)                                    BSSM1
      IF(I2-1)140,140,150                                                BSSM1
  140 MP=NPT                                                             BSSM1
      DO 145 I=1,3                                                       BSSM1
  145 M1(I)=W(1,I)                                                       BSSM1
  150 IF(NPT-MP)160,170,160                                              BSSM1
  160 MP=NPT                                                             BSSM1
      NP=NP+1                                                            BSSM1
      MPT(NP)=0                                                          BSSM1
  170 MPT(NP)=MPT(NP)+1                                                  BSSM1
  180 CONTINUE                                                           BSSM1
      CALL FMASK(M1(3))                                                  BSSM1
      NPTFO=0                                                            BSSM1
      IF(LTI)260,190,260                                                 BSSM1
  190 LTI=1                                                              BSSM1
  200 REWIND NT                                                          BSSM1
      CALL FSKPD(NT,NFG)                                                 BSSM1
      IF(NFG-1)210,201,202                                               BSSM1
  201 PRINT 5200,NT                                                      BSSM1
```

```
      GO TO 470                                                         BSSM1
  202 PRINT 5300,NT                                                     BSSM1
      GO TO 470                                                         BSSM1
  210 CALL FTSRINT,WO(NW),NW,NFG)                                       BSSM1
      IF(NFG-1)215,205,270
  205 PRINT 5400,NR,NT                                                  BSSM1
      GO TO 470                                                         BSSM1
  215 NR=NR+1                                                           BSSM1
      DO 211 JKL=1,2700
      LKJ=2701-JKL
  211 WO(JKL)=WO(LKJ)                                                   BSSM1
      DO 260 II=1,2700,45                                               BSSM1
      II=II                                                             BSSM1
      DO 220 J=1,3                                                      BSSM1
      J1=II+J-1                                                         BSSM1
  220 W2(J)=WO(J1)                                                      BSSM1
      CALL FMASK(W2(3))                                                 BSSM1
      DO 230 J=1,3                                                      BSSM1
      CALL FCOMP(W1(J),W2(J),NCOMP)                                     BSSM1
      IF(NCOMP)250,230,250                                              BSSM1
  230 CONTINUE                                                          BSSM1
      CALL FINCR(NPTS,LR)                                               BSSM1
      NPTFO=NPTFO+1                                                     BSSM1
      KFL=1                                                             BSSM1
      DO 240 I=1,45                                                     BSSM1
      I6=II+I-1                                                         BSSM1
  240 WF(NPTFO,I)=WO(I6)                                                BSSM1
      GO TO 260                                                         BSSM1
  250 IF(KFL)330,260,330                                                BSSM1
  260 CONTINUE                                                          BSSM1
      CALL FINCR(NFOTP,INCR)                                            BSSM1
      GO TO 210                                                         BSSM1
  270 CALL F2FLD(NT,NFD,NFG)                                            BSSM1
      IF(NFG-1)278,271,272                                              BSSM1
  271 PRINT 5600,NT                                                     BSSM1
      GO TO 470                                                         BSSM1
  272 PRINT 5700,NT                                                     BSSM1
      GO TO 470                                                         BSSM1
  278 CALL FCOMP(NFOTP,NFD,NCOMP)                                       BSSM1
      IF(NCOMP)280,290 ,280                                             BSSM1
  280 PRINT 5710,NT,NFD,NFOTP                                           BSSM1
      PAUSE                                                             BSSM1
  290 REWIND NT                                                         BSSM1
      NFOTP=0                                                           BSSM1
      IF(SENSE SWITCH 2)300,310                                         BSSM1
  300 NT=15                                                             BSSM1
      LTI=0                                                             BSSM1
      GO TO 100                                                         BSSM1
  310 NOT=NOT+1                                                         BSSM1
      NT=NT+1                                                           BSSM1
      IF(NTO-NOT)440,440,315                                            BSSM1
  315 IF(17-NT)320,200,200                                              BSSM1
  320 NT=15                                                             BSSM1
      PRINT 5020                                                        BSSM1
      PAUSE
```

```
      GO TO 200                                                  BSSM1
  330 WRITE TAPE NTO,NP,(MPT(I),I=1,NP)                          BSSM1
      L2=0                                                       BSSM1
      DO 340 I=1,NP                                              BSSM1
      WRITE TAPE NTO,(WF(I,J),J=1 ,45)                           BSSM1
      L1=L2+1                                                    BSSM1
      L2=L2+MPT(I)                                               BSSM1
  340 WRITE TAPE NTO,((M(J,K),K=3,8),J=L1,L2)                    BSSM1
      NBDC=NBDC+1                                                BSSM1
      IF(XMODF(NPF,45))350,350,360                               BSSM1
  350 NPG=NPG+1                                                  BSSM1
      PRINT 5090,NPG                                             BSSM1
      PRINT 5030                                                 BSSM1
  360 NPF=NPF+1                                                  BSSM1
      TIST(1)=WF(1,1)                                            BSSM1
      CALL FSHFT(WF(1,1),TIST(2),LL,L24)                         BSSM1
      TIST(3)=WF(1,2)                                            BSSM1
      CALL FSHFT(WF(1,2),TIST(4),LL,L12)                         BSSM1
      CALL FSHFT(WF(1,2),TIST(5),LL,L24)                         BSSM1
      TIST(6)=WF(1,3)                                            BSSM1
      CALL FSHFT(WF(1,3),TIST(7),LL,L30)                         BSSM1
      TIST(8)=WF(1,4)                                            BSSM1
      CALL FSHFT(WF(1,4),TIST(9),LL,L6)                          BSSM1
      CALL FSHFT(WF(1,8),WF(1,8),LL,L24)                         BSSM1
      PRINT 5040,(TIST(I),I=1,9),(WF(1,J),J=5,10)                BSSM1
      IF(NP-1)405,405,370                                        BSSM1
  370 DO 400 I=2,NP                                              BSSM1
      CALL FSHFT(WF(I,3),TIST(7),LL,L30)                         BSSM1
      TIST(8)=WF(I,4)                                            BSSM1
      CALL FSHFT(WF(I,4),TIST(9),LL,L6)                          BSSM1
      IF(XMODF(NPF,45))380,380,390                               BSSM1
  380 NPG=NPG+1                                                  BSSM1
      PRINT 5090,NPG                                             BSSM1
      PRINT 5030                                                 BSSM1
      PRINT 5040,(TIST(J),J=1,9),(WF(I,K),K=8,10)                BSSM1
      GO TO 400                                                  BSSM1
  390 PRINT 5050,(TIST(J),J=7,9)                                 BSSM1
  400 NPF=NPF+1                                                  BSSM1
  405 DO 410 I=1,II                                              BSSM1
      CALL FSHFT(M(I,7),PF,LL,L18)                               BSSM1
      CALL PFCAT(PF,IP)
      IP=IP+1                                                    BSSM1
  410 MPF(IP)=MPF(IP)+1                                          BSSM1
      KFL=0                                                      BSSM1
      IF(NPTFC-NP)420,430,420                                    BSSM1
  420 PRINT 5100,NT,NR,II                                        BSSM1
      PAUSE                                                      BSSM1
      GO TO 470                                                  BSSM1
  430 IF(NSLD-NBDC)440,450,100                                   BSSM1
  440 PRINT 5060                                                 BSSM1
  450 PRINT 5110,NPTG                                            BSSM1
      ENDFILE NTO                                                BSSM1
      REWIND NTO                                                 BSSM1
      REWIND NT                                                  BSSM1
      REWIND LT
```

```
                                                                        BSSM1
      PRINT 5070                                                        BSSM1
      DO 460 I=1,9                                                      BSSM1
      IP=I-1                                                            BSSM1
  460 PRINT 5080,IP,NPF(I)                                              BSSM1
  470 CALL ENDJOB                                                       BSSM1
 5000 FORMAT(2I10)                                                      BSSM1
 5010 FORMAT(1H1,9X,37HFOSDIC COUNT DOES NOT CHECK FOR TAPE I2//10X,16HT BSSM1
     1HE TAPE COUNT IS O12//10X,22HTHE COMPUTER COUNT IS O12//10X,23HPUS BSSM1
     2H START TO CONTINUE.////////)                                     BSSM1
 5020 FORMAT(1H1,9X,43HTHE PROGRAM IS READY TO READ TAPE BE AGAIN.//10X, BSSM1
     127HHAS THIS TAPE BEEN CHANGED.//10X,30HIF SO, PUSH START TO CONTIN BSSM1
     2UE.////////)                                                      BSSM1
 5030 FORMAT(1H0,9X,45HSTAND LOC   FC   CC   FAC NO   PT NO   REV NO,20X BSSM1
     1,13HFACILITY NAME//)                                              BSSM1
 5040 FORMAT(10X,A4,1H-,2A2,3X,A2,3X,A1,4X,A5,4X,2A1,8X,A1,6X,A2,5A6)   BSSM1
 5050 FORMAT(42X,2A1,8X,A1)                                             BSSM1
 5060 FORMAT(1H1,9X,75HTHE END OF THE LAST TAPE HAS BEEN REACHED.  THIS  BSSM1
     1IS AN ABNORMAL TERMINATION//)                                     BSSM1
 5070 FORMAT(1H0,9X,11HPF CATEGORY,10X,15HNO. OF SHELTERS)              BSSM1
 5080 FORMAT(1H0,14X,I1,17X,I10)                                        BSSM1
 5090 FORMAT(1H1,100X,4HPAGE,I4)                                        BSSM1
 5100 FORMAT(1H1,9X,68HNUMBER OF PARTS FROM SHELTER AND FOSDIC TAPES DO  BSSM1
     1NOT AGREE FOR TAPE I2,8H RECORD I10,6H WORD I10//)                BSSM1
 5110 FORMAT(1H1,9X,40HTOTAL NUMBER OF FOSDIC ENTRIES SELECTED O12//)   BSSM1
 5200 FORMAT(1H1,9X,58HTAPE CHECK ENCOUNTERED WHILE READING FIRST RECORD BSSM1
     1 ON TAPE I2//)                                                    BSSM1
 5300 FORMAT(1H1,9X,51HEOF ENCOUNTERED WHILE READING FIRST RECORD ON TAP BSSM1
     1E I2//)                                                           BSSM1
 5400 FORMAT(1H1,9X,44HTAPE CHECK ENCOUNTERED WHILE READING RECORD I2,9H BSSM1
     1 ON TAPE I2//)                                                    BSSM1
 5600 FORMAT(1H1,9X,57HTAPE CHECK ENCOUNTERED WHILE READING SECOND FILE  BSSM1
     1ON TAPE I2//)                                                     BSSM1
 5700 FORMAT(1H1,9X,50HEOF ENCOUNTERED WHILE READING SECOND FILE ON TAPE BSSM1
     1 I2//)                                                            BSSM1
      END
```

```
C     BUILDING SAMPLE PRINTOUT PROGRAM NUMBER ONE                        BSPO
C         H.G. NORMENT,  RESEARCH TRIANGLE                               BSPO
C                                                                        BSPO
      DIMENSION          TLE(27),WF(45 )  ,WS( 200,6),MPT(100 ),N17(7),  BSPO
     1 N18(4),N19(19),N20(24),N22(4),N23A(16),N23B(12),N23C(12),N23D(16) BSPO
     2,NSH(13),X(6)                                                      BSPO
      NPG1=0                                                             BSPO
      NPG2=C                                                             BSPO
      NT=6
      NO1=15
      NO2=16                                                             BSPO
      REWIND NT                                                          BSPO
      REWIND NO1                                                         BSPO
      REWIND NO2                                                         BSPO
      READ 4000,NBLD                                                     BSPO
      DO 190 IJ=1,NBLD                                                   BSPO
      LINE=51                                                            BSPO
      READ TAPE NT,NP,(MPT(I),I=1,NP)                                    BSPO
      DO 180 I=1,NP                                                      BSPO
      L=MPT(I)                                                           BSPO
      READ TAPE NT,(WF(J),J=1,45)                                        BSPO
      READ TAPE NT,((WS(J,K),K=1,6),J=1,L)                               BSPO
      CALL F01T16(WF,TLE)                                                BSPO
      CALL F017(WF,N17)                                                  BSPO
      CALL F018(WF,N18)                                                  BSPO
      CALL F019(WF,N19)                                                  BSPO
      CALL F020(WF,N20)                                                  BSPO
      CALL F021(WF,N21)                                                  BSPO
      CALL F022(WF,N22)                                                  BSPO
      CALL F023A(WF,N23A)                                                BSPO
      CALL F023B(WF,N23B)                                                BSPO
      CALL F023C(WF,N23C)                                                BSPO
      CALL F023D(WF,N23D                                                 BSPO
      NPG1=NPG1+1                                                        BSPO
      WRITE OUTPUT TAPE NO1,5000,NPG1
      WRITE OUTPUT TAPE NO1,6000,TLE(27),(TLE(J),J=4,12),(TLE(J),J=1,3),
     1(TLE(J),J=13,26)                                                   BSPO
      WRITE OUTPUT TAPE NO1,6010,N17(1),N17(2),N18(1),N17(3),N17(4),     BSPO
     1 N18(2),N17(5),N17(6),N18(3),N17(7),N18(4)                         BSPO
      WRITE OUTPUT TAPE NO1,6020,(N19(J),J=1,19)                         BSPO
      WRITE OUTPUT TAPE NO1,6030,(N20(J),J=1,24)                         BSPO
      WRITE OUTPUT TAPE NO1,6040,N21,(N22(J),J=1,4)                      BSPO
      WRITE OUTPUT TAPE NO1,6050,(N23A(J),J=1,16)                        BSPO
      WRITE OUTPUT TAPE NO1,6060,(N23B(J),J=1,12)                        BSPO
      WRITE OUTPUT TAPE NO1,6070,(N23C(J),J=1,12)                        BSPO
      WRITE OUTPUT TAPE NO1,6080,(N23D(J),J=1,16)                        BSPO
      IF(51-LINE)100,100,110                                             BSPO
  100 NPG2=NPG2+1                                                        BSPO
      WRITE OUTPUT TAPE NO2,5000,NPG2                                    BSPO
      WRITE OUTPUT TAPE NO2,5010,TLE(1),TLE(2),TLE(3),TLE(13),TLE(14),   BSPO
     1 TLE(15)                                                           BSPO
      LINE=3                                                             BSPO
  110 LINE=LINE+1                                                        BSPO
      IF(51-LINE)100,100,120                                             BSPO
  120 WRITE OUTPUT TAPE NO2,5020,TLE(16),TLE(17),TLE(19),TLE(18),TLE(20  BSPO
```

```
 1),TLE(4),(TLE(J),J=5,12),TLE(23),TLE(24),TLE(22),TLE(21),N21      BSPO
      LINE=LINE+1                                                    BSPO
      IF(51-LINE)100,100,130                                         BSPO
  130 WRITE OUTPUT TAPE NO2,5030                                     BSPO
      LINE=LINE+1                                                    BSPO
      IF(51-LINE)100,100,150                                         BSPO
  150 DO 170 K2=1,L                                                  BSPO
      DO 155 K3=1,6
  155 J(K3)=KS(K2,K3)
      CALL SHELTI(K,MSH)
      WRITE OUTPUT TAPE NO2,5040,(J(I),I=1,6)                        BSPO
      LINE=LINE+1                                                    BSPO
      IF(51-LINE)160,160,170                                         BSPO
  160 NPG2=NPG2+1                                                    BSPO
      WRITE OUTPUT TAPE NO2,5000,NPG2                                BSPO
      WRITE OUTPUT TAPE NO2,5010,TLE(1),TLE(2),TLE(3),TLE(13),TLE(14), BSPO
     1 TLE(15)                                                       BSPO
      WRITE OUTPUT TAPE NO2,5020,TLE(16),TLE(17),TLE(19),TLE(18),TLE(20 BSPO
     1),TLE(4),(TLE(J),J=5,12),TLE(23),TLE(24),TLE(22),TLE(21),N21   BSPO
      WRITE OUTPUT TAPE NO2,5030                                     BSPO
      LINE=6                                                         BSPO
  170 CONTINUE                                                       BSPO
  180 CONTINUE                                                       BSPO
  190 CONTINUE                                                       BSPO
      REWIND MT                                                      BSPO
      END FILE NO1                                                   BSPO
      END FILE NO2                                                   BSPO
      REWIND NO1                                                     BSPO
      REWIND NO2                                                     BSPO
      PRINT 4010                                                     BSPO
      CALL ENDJOB                                                    BSPO
 5000 FORMAT(1H1,109X,5HPAGE I5)                                     BSPO
 5010 FORMAT(4HOSL=A4,1H-,2A2,5H  FL=A2,4H  C=A2,6H  FAC=A5)         BSPO
 5020 FORMAT(1HO,6X,3HPT=2A1,4H OF A2,5H  REV=A1,4H ST=A2,4X,A2,6A6,6H BSPO
     1USE=A2,5H CAN=A1,4H FY=A2,6H YEAR=A4,4H SM=I1)                 BSPO
 5030 FORMAT(45X,75HSTORY  A   B   C   D   CL  TOT  PF  FLOOR   S-AREA BSPO
     1 CORE   VOLUME   PEOPLE)                                       BSPO
 5040 FORMAT(46X,6I4,I5,I4,3I8,I9,I7)                                BSPO
 4000 FORMAT(I10)                                                    BSPO
 4010 FORMAT(1H1,9X,45HSAVE TAPE A6, PRINT AND SAVE TAPES B5 AND B6.//// BSPO
     1////)                                                          BSPO
 6000 FORMAT(83X,13H(1) PAGE NO. A2/21X,5H(2)  A2,8A6,7X,7H(3)   A4,2A2 BSPO
     1//21X,77H (4)   (5)   (6)   (7)   (8)   (9)  (10)  (11)  (12)  (1 BSPO
     23)  (14)  (15)  (16)/24X,A2,4X,A2,1X,A5,4X,2A1,5X,A1,4X,A2,4X,A2,2
     3X,A4,4X,A2,4X,A2,5X,A1,5X,A1,5X,A1)
 6010 FORMAT(1HO,20X,49H(17) AREA DIMENSIONS   SIDE A      SIDE B    ( BSPO
     118) HEIGHT/25X,14HEXTERIOR WALLSI8,I12,13X,8HTOTAL    I9/28X,14HCO BSPO
     2RE 1ST STORYI8,I12,13X,8HBASEMENTI9/28X,16HCORE UPPER STORYI6,I12, BSPO
     313X,7H1ST STORYI5/28X,16HBASEMENT PERCENTI6,9X,3H***,13X,11HUPPER BSPO
     4STORYI6)                                                       BSPO
 6020 FORMAT(1HO,20X,77H(19) ROOF AND SETBACK  HEIGHT      SIDE A     S BSPO
     1IDE B      SIDE C      SIDE D/25X,4HROOF,15X,3H***,4I12/28X,13HSET BSPO
     2BACK NO. 1I9,4I12/28X,13HSETBACK NO. 2I9,4I12/28X,13HSETBACK NO. 3 BSPO
     3I9,4I12)                                                       BSPO
 6030 FORMAT(1HO,20X,77H(20) CONTAMINATED PLANES          SIDE A      S BSPO
```

```
     1IDE B        SIDE C        SIDE D/28X,27HPLANE 1     EFFECTIVE HEIGHTI7
     2,3I12/39X,14HWIDTH OF PLANEI9,3I12/28X,27HPLANE 2     EFFECTIVE HEI BSPO
     3GHTI7,3I12/39X,14HWIDTH OF PLANEI9,3I12/28X,27HPLANE 3     EFFECTIV BSPO
     4E HEIGHTI7,3I12/39X,14HWIDTH OF PLANEI9,3I12)                        BSPO
6040 FORMAT(1H0,20X,23H(21) SURVEY METHOD CODEI6//21X,77H(22) FLOOR AND BSPO
     1 ROOF DESCPIPTION  BASEMENT    1ST FLOOR   UPPER FLOORS      ROOF/50 BSPO
     2X,4I12)                                                              BSPO
6050 FORMAT(1H0,20X,21H(23) STRUCTURE DETAIL/56X,42HSIDE A       SIDE B  BSPO
     1      SIDE C       SIDE D/28X,24HBASEMENT  EXTERIOR WALLSI10,3I12/38 BSPO
     2X,15HHGT ABOVE GRADEI9,3I12/38X,14HAPERTURES      I10,3I12/38X,14HI BSPO
     3NTERIOR WALLSI10,3I12)                                               BSPO
6060 FORMAT(1H0,27X,24H1ST STORY EXTERIOR WALLSI10,3I12/38X,14HAPERTURE BSPO
     1S      I10,3I12/38X,14HINTERIOR WALLSI10,3I12)                       BSPO
6070 FORMAT(1H0,27X,24HUPPER      EXTERIOR WALLSI10,3I12/38X,14HAPERTURE BSPO
     1S      I10,3I12/38X,14HINTERIOR WALLSI10,3I12)                       BSPO
6080 FORMAT(1H0,27X,21HUPPER AFTER CONSTRUCTION CHANGE/38X,14HNO CHANGE BSPO
     1      ,9X,1HX,3(11X,1HX)/38X,14HSTORY NUMBER  I10,3I12/38X,14HEXTER BSPO
     2IOR WALLSI10,3I12/38X,14HAPERTURES      I10,3I12/38X,14HINTERIOR WA BSPO
     3LLSI10,3I12)                                                         BSPO
      END                                                                  BSPO
```

```
        ENTRY   RNDM
        ENTRY   RSEED
RNDM    STO     K          STORE INTERVAL WIDTH
        CLA     A          TEST TO SEE IF X-ZERO IS ZERO
        TNZ     B          NO  COMPUTE PSEUDO-RANDOM NUMBER
        SXD     A,4        YES  COMPUTE NEW X-ZERO BY LOGICALLY
     C  ACL     0,4        SUMMING STORAGE FROM LOCATION OF TSX RNDM,4
        TIX     C,4,1      TO 77777.
        LXD     A,4
        ARS     5          SHIFT OFF LOW ORDER BITS
        STO     A          STORE IN X-ZERO
     B  LDQ     A          MULTIPLY X-ZERO
        MPY     A-1        BY LAMBDA
        LLS     4          GET 4 ZERO BITS IN LEFT OF
        ALS     4          MQ AND AC
        LRS     4
        STQ     A
        ADD     A          ADD MQ TO AC
        STO     A          STOPE NEW X-ZERO
        ARS     4          SHIFT OFF LOW ORDER BITS
        ORA     A-2
        FAD     A-2        FLOAT X
        LDQ     K
        SLW     K          MAP X INTO THE REQUIRED INTERVAL.
        FMP     K          I.E. (0.TO K)
        TRA     1,4        RETURN
        TIX     0
        HTR     991        MULTIPLIER
     A  HTR     0
     K  HTR     0
RSEED   CLA*    1,4        GET SEED
        STO     A          STORE IT
        TRA     2,4        RETURN
        END
```

```
        ENTRY   FTPRD
        HTR
        HTR
FTPRD   SXD     *-1,1       NT,NTR,PW,NFG
        SXD     *-3,2
        CLA     3,4         READ RECORD OF8
        STA     DCCOM       BCD WORDS FROM TAPE
        AXT     5,1         NT OF CHANNEL B.
        CLA*    1,4         STORE PW(1-8).
        PDC     0,2         EXTRACT DEC PW(1)
B       RDS     1142,2      AND STORE IN DEC
        RCHB    DCCOM       OF NTR. IF TAPE
        TCOB    *           CHECK (5X),NFG=1.
        TRCB    CHK         IF END FILE,NFG=2.
        TEFB    EFL         IF NEITHER,NFG=0.
        CAL*    3,4
        STD*    2,4
        CLA     BLANK
C       STO*    4,4
        LXD     FTPRD-1,1
        LXD     FTPRD-2,2
        TRA     5,4
DCCOM   IOCD    0,,8
BLANK   HTR
CHK     BSR     1142,2
        TCOB    *
        TIX     B,1,1
        CLA     IND
        TRA     C
EFL     CLA     IND+1
        TRA     C
IND     OCT     000001000000
        OCT     000002000000
        END
```

```
         ENTRY   FTSR
         HTR
         HTR
FTSR     SXD     *-1,1          NT,WO,NW,NFG
         SXD     *-3,2
         CLA     2,4            READ ONE BIN RECORD
         STA     DCOM           OF NW WORDS FROM B
         CLA*    3,4            CHANNEL TAPE NT AND
         STD     DCOM           STORE STARTING AT WO
         AXT     2,1
         CLA*    1,4            IF TAPE CHECK(2X),
         PDC     0,2               NFG=1
B        RDS     1158,2         IF EOF,NFG=2.
         RCHB    DCOM           IF NEITHER,NFG=0.
         TCOB    *
         TRCB    CHK
         TEFB    EFL
         CLA     BLANK
C        STO*    4,4
         LXD     FTSR-1,1
         LXD     FTSR-2,2
         TRA     5,4
DCOM     IOCD
CHK      BSR     1158,2
         TCOB    *
         TIX     B,1,1
         CLA     BLANK+1
         TRA     C
EFL      CLA     BLANK+2
         TRA     C
BLANK    HTR
         OCT     000001000000
         OCT     000002000000
         END



         ENTRY   FPTNO
FPTNO    CAL*    1,4            (1,,2,)
         ANA     MASK
         LRS     35
         MPY     MASK+1         EXTRACT PART
         STQ     MASK+2         NO. FROM FOSDIC
         CAL*    2,4
         ARS     30
         ADD     MASK+2
         ALS     18
         STO*    3,4
         TRA     4,4
MASK     OCT     000000000077
         OCT     000000000012
         HTR
         END
```

```
        ENTRY   FSKPD
        HTR
        HTR
FSKPD   SXD     *-1,1
        SXD     *-3,2       NT,NFG
        AXT     5,2
        CLA*    1,4         SKIP OVER ONE
        PDC     0,1         12 WORD BCD
A       RDS     1142,1      RECORD
        RCHP    DCCOM
        TCOB    *           IF REDUN. CHK,NFG=1
        TRCB    CHK         IF EOF NFG=2
        TEFB    EOF         OTHERWISE NFG=0
        CLA     DCCOM+1
B       STO*    2,4
        LXD     FSKPD-1,1
        LXD     FSKPD-2,2
        TRA     3,4
DCCOM   IOCDN   0,,12
        HTR
CHK     BSR     1142,1
        TCOB    *
        TIX     A,2,1
        CLA     EOF+2
        TRA     B
EOF     CLA     *+3
        TRA     B
        HTR     0,0,1
        HTR     0,0,2
        END
```

```
       ENTRY   F2FLD
       HTR
       HTR
F2FLD  SXD     *-1,1              NT,NFD,NFG
       SXD     *-3,2
       AXT     5,1
       CLA*    1,4
       PDC     0,2
B      RDS     1158,2
       RCHB    DCOM
       TCOB    *
       TRCB    CHK
       TEFB    EFL
       CLA     BLANK
C      STO*    3,4
       CLA     DCOM+1
       ALS     18
       STO*    2,4
       LXD     F2FLD-1,1
       LXD     F2FLD-2,2
       TRA     4,4
DCOM   IOCD    *+1,,1
       HTR
CHK    BSR     1158,2
       TCOB    *
       TIX     B,1,1
       CLA     BLANK+1
       TRA     C
EFL    CLA     BLANK+2
       TRA     C
BLANK  HTR
       OCT     000001000000
       OCT     000002000000
       END
```

Appendix C

Source Program Listings for Statistical Analysis

I. INTRODUCTION

This appendix gives a brief description of the computer programs used exclusively for the statistical study of the sample building structural characteristics and the relations of these characteristics to shielding effectiveness (see Chapter 3). Source program listings are included. Subroutines used in the calculations but not listed herein are discussed in Appendix D.

II. PROGRAM DESCRIPTIONS

A. SHSTAT is the executive program. It reads the sample tape and accumulates the the statistics.

B. STAPUT outputs shelter statistics.

C. FINPUT outputs totaled shelter statistics (by calling STAPUT) and building statistics.

D. FOSPUT outputs the M1 file data for each building part (see Figure 3 of Chapter 3).

E. FOSCAL called instead of FOSPUT if the M1 and M2 file data output is not wanted.

F. SETUP calculates totals, mean PF, and standard deviations for each shelter or building characteristic.

G. GOOL calculates and accumulates data from which means and standard deviations of building and shelter characteristics with discrete distributions are to be calculated.

H. COOL calculates and accumulates data from which means and standard deviations of building and shelter characteristics with continuous distribution are to be calculated.

I. TOOL calculates means and standard deviations of building characteristics for each PF category.

III. SOURCE PROGRAM LISTINGS

```
C     FALLOUT SHELTER CATEGORIZATION STATISTICAL STUDY                  SHSTAT
C                                                                       SHSTAT
      DIMENSION             IFL( 45,8),IFLP(45 ,8),JFLP(45 ,8),         SHSTAT
     1             IAP(10,8),IAPP(10,8),JAPP(10,8),IIPT(8),  IIP(8)     SHSTAT
     2,JIP(8),              IPL(100,8),IPLP(100,8),                     SHSTAT
     3IAR(5,8),IARP(5,8),JARP(5,8),        JPV (91,8),                  SHSTAT
     4 IPS(20,8),IPSP(20,8),JPSP(20,8),IDZ(5,8),IDZP(5,8),
     5MPT(50),WF(45),WS(6,45) ,NR(2),       N17(7),N18(4),N19(19),N20(2 SHSTAT
     64),N22(4),N23A(16),N23B(12),N23C(12),N23D(16),NSH(13),TLE(27)     SBSTIT
      DIMENSION  MHT(
     14),MPL(4),WF1(20,45),WS1(20,45,6),INPT(20,8), IBZ(10,8)           S''STAT
      LL=0                                                              SHSTAT
      LR=1                                                              SHSTAT
      L18=18                                                            SHSTAT
      L12=12
      MP=0                                                              SHSTAT
      NT1=15                                                            SHSTAT
      NT2=16                                                            SHSTAT
      L8=5                                                              SHSTAT
      L24=24                                                            SHSTAT
      L30=30                                                            SHSTAT
      L6=6                                                              SHSTAT
      NTS=5                                                             SHSTAT
      NTT=6                                                             SHSTAT
      MSUB=0
      READ 1000,NBLD,KPTO                                               SHSTAT
      DO 90 I=1,20                                                      SHSTAT
      DO 90 J=1,8                                                       SHSTAT
      IPS(I,J)=0                                                        SHSTAT
      JPSP(I,J)=0                                                       SHSTAT
   90 INPT(I,J)=C                                                       SHSTAT
      DO 100 I=1,45                                                     SHSTAT
      DC 100 J=1,8                                                      SHSTAT
      IFL(I,J)=0                                                        SHSTAT
  100 JFLP(I,J)=0                                                       SHSTAT
      DC 101 I=1,10                                                     SHSTAT
      DO 101 J=1,8                                                      SHSTAT
      IBZ(I,J)=C
      IAP(I,J)=0                                                        SHSTAT
  101 JAPP(I,J)=C                                                       SHSTAT
      CC 102 I=1,8                                                      SHSTAT
      JIP(I)=C                                                          SHSTAT
  102 IIPT(I)=0                                                         SHSTAT
      DO 103 I=1,100                                                    SHSTAT
      DC 103 J=1,8                                                      SHSTAT
  103 IPL(I,J)=0                                                        SHSTAT
      DO 1C4 I=1,5                                                      SHSTAT
      DC 104 J=1,8
      IAR(I,J)=0                                                        SHSTAT
      IDZ(I,J)=0                                                        SHSTAT
  104 JARP(I,J)=0                                                       SHSTAT
      CO 105 I=1,91                                                     SHSTAT
      CC 1C5 J=1,8                                                      SHSTAT
  1C5 JPV(I,J)=0                                                        SHSTAT
  110 REWIND NTS                                                        SHSTAT
      REWIND NT1                                                        SHSTAT
      REWIND NT2                                                        SHSTAT
      REWIND NTT                                                        SHSTAT
      NBLD1=0                                                           SHSTAT
      DC 120 I=1,2                                                      SHSTAT
```

```
120 NR(1)=0                                                    SMSTAT
    DO 230 IJ=1,NBLD                                           SMSTAT
    READ TAPE NTS,NP,(MPT(I),I=1,NP)                           SMSTAT
    PMT=0.0                                                    SMSTAT
    DO 180 I=1,NP                                              SMSTAT
    L=MPT(I)                                                   SMSTAT
    READ TAPE NTS,(MF1(I,J),J=1,45)                            SMSTAT
    READ TAPENTS,((MS1(I,J,K),K=1,6),J=1,L)                    SMSTAT
    DO 180 J=1,L                                               SMSTAT
    CALL FSHFT(MS1(I,J,2),LSTR,0,20)
    CALL FTSH(LSTR,LSTR,1,10)
    IF(LSTR)130,160,160
130 IF(MP)131,131,180
131 PSUB=PSUB+1
    GO TO 180                                                  SMSTAT
160 CALL FSHFT(MS1(I,J,5),PM,LL,L10)                           SMSTAT
    IF(PMT-PM)170,180,180                                      SMSTAT
170 PMT=PM                                                     SMSTAT
180 CONTINUE                                                   SMSTAT
    CALL PFCAT(PMT,NPF)                                        SMSTAT
    NPF=NPF-MP
    IF(PPF)230,230,181                                         SMSTAT
181 IF(2-NPF)190,201,200                                       SMSTAT
190 NPF=NTT                                                    SMSTAT
    NBLD1=NBLD1+1                                              SMSTAT
    GO TO 205                                                  SMSTAT
200 NR(1)=NR(1)+1                                              SMSTAT
    NPF=NT1                                                    SMSTAT
    GO TO 205                                                  SMSTAT
201 NPF=NT2                                                    SMSTAT
    NR(2)=NR(2)+1                                              SMSTAT
205 WRITE TAPE NPF,NP,(MPT(I),I=1,NP)                          SMSTAT
    DO 220 I=1,NP                                              SMSTAT
    L=MPT(I)                                                   SMSTAT
    WRITE TAPE NPF,(MF1(I,J),J=1,45)                           SMSTAT
220 WRITE TAPE NPF,((MS1(I,J,K),K=1,6),J=1,L)                  SMSTAT
230 CONTINUE                                                   SMSTAT
    REWIND NTT                                                 SMSTAT
    REWIND NT1                                                 SMSTAT
    REWIND NT2                                                 SMSTAT
    REWIND NTS                                                 SMSTAT
    NT=NT1-1                                                   SMSTAT
    DO 350 IJ=1,2                                              SMSTAT
    NT=NT+1                                                    SMSTAT
    NB=NR(IJ)
    IF(NB)350,350,1150                                         SMSTAT
1150 DO 155 J=1,6                                              SMSTAT
    DO 150 I=1,45                                              SMSTAT
150 IFLP(I,J)=0                                                SMSTAT
    DO 151 I=1,10                                              SMSTAT
151 IAPP(I,J)=0                                                SMSTAT
    DO 152 I=1,100                                             SMSTAT
152 IPLP(I,J)=0                                                SMSTAT
    DO 153 I=1,5                                               SMSTAT
    IARP(I,J)=0                                                SMSTAT
153 ICZP(I,J)=0
    DO 154 I=1,20                                              SMSTAT
154 IPSP(I,J)=0                                                SMSTAT
155 IIP(J)=0                                                   SMSTAT
    MPF=IJ+MP
    IF(KPTD)1156,1155,1156
```

```
1155 PRINT 1100,NPF                                                       SHSTAT
     NPG1=0                                                               SHSTAT
1156 DO 330 I=1,NB                                                        SHSTAT
     ART=0.                                                               SHSTAT
     NSTR=0                                                               SHSTAT
     NIPP=0                                                               SHSTAT
     NSTR=0                                                               SHSTAT
     READ TAPE NT,NP,(NPT(IN),IN=1,NP)                                    SHSTAT
     NAP=0                                                                SHSTAT
     NPV=0                                                                SHSTAT
     NPS=0                                                                SHSTAT
     DO 320 J=1,NP                                                        SHSTAT
     L=NPT(J)                                                             SHSTAT
     READ TAPE NT,(WF(K),K=1,45)                                          SHSTAT
     READ TAPE NT,((WS(M,K),M=1,6),K=1,L)                                 SHSTAT
     IF(KPTO)156,157,156
 156 CALL FOSCAL(      WF,TLE,N17,N18,N19,         N20,N21,N22,N23A,N23B, SHSTAT
    1N23C,N23D)
     GO TO 158
 157 CALL FOSPUT(NPG1,WF,TLE,N17,N18,N19,         N20,N21,N22,N23A,N23B, SHSTAT
    1N23C,N23D)                                                           SHSTAT
 158 CALL FNASH(WF(5),NR1,L6,L30,L12,LR)                                  SHSTAT
     CALL FNASH(WF(5),NR2,L6,L24,L6,LR)                                   SHSTAT
     NR1=NR1*10+NR2+1                                                     SHSTAT
     IF(NSTR-NR1)231,232,232                                              SHSTAT
 231 NSTR=NR1                                                             SHSTAT
 232 CALL FNASH(WF(6),NPV1,L6,L30,L12,LR)                                 SHSTAT
     CALL FNASH(WF(6),NPV2,L6,L24,L6,LR)                                  SHSTAT
     NPV1=NPV1*10+NPV2                                                    SHSTAT
     IF(NPV-NPV1)233,234,234                                              SHSTAT
 233 NPV=NPV1                                                             SHSTAT
 234 AR1=N17(1)                                                           SHSTAT
     AR1=AR1/100.                                                         SHSTAT
     AR2=N17(2)                                                           SHSTAT
     AR=AR1+AR2                                                           SHSTAT
     ART=ART+AR                                                           SHSTAT
     MAR=LOG10F(AR )+1.                                                   SHSTAT
     IF(MAR)235,235,236                                                   SHSTAT
 235 MAR=1                                                                SHSTAT
     GO TO 238                                                            SHSTAT
 236 IF(MAR-5)238,238,237                                                 SHSTAT
 237 MAR=5
 238 IF(KPTO)260,239,260
 239 NPG1=NPG1+1                                                          SHSTAT
     PRINT 5000,NPG1                                                      SHSTAT
     PRINT 5010,TLE(1),TLE(2),TLE(3),TLE(13),TLE(14),TLE(15)              SHSTAT
     PRINT 5020,TLE(16),TLE(17),TLE(19),TLE(18),TLE(20),TLE(4),(TLE(K),   SHSTAT
    1K=5,12),TLE(23),TLE(24),TLE(22),TLE(21),N21                          SHSTAT
     PRINT 5030                                                           SHSTAT
 260 DO 310 K2=1,L                                                        SHSTAT
     CALL SHELT(WS(1,K2),NSH)                                             SHSTAT
     K4=NSH(8)                                                            SHSTAT
     IF(K4)310,310,1260
1260 IF(KPTO)1262,1261,1262                                               SHSTAT
1261 PRINT 5040,(NSH(K3),K3=1,13)                                         SHSTAT
1262 IF(NSH(1))310,262,262                                                SHSTAT
 262 NSH1=NSH(1)+1                                                        SHSTAT
     IFLP(NSH1,K4)=IFLP(NSH1,K4)+1                                        SHSTAT
     IF(NSH(1)-1)263,266,269                                              SHSTAT
 263 NB=N18(2)
```

```
1155 PRINT 1100,NPF                                                    SHSTAT
     NPG1=0                                                            SHSTAT
1156 DO 330 I=1,NB                                                     SHSTAT
     ART=0.                                                            SHSTAT
     MSTR=0                                                            SHSTAT
     MIPP=0
     NSTR=0                                                            SHSTAT
     READ TAPE NT,NP,(NPT(IN),IN=1,NP)                                 SHSTAT
     MAP=0                                                             SHSTAT
     MPV=0                                                             SHSTAT
     MPS=0                                                             SHSTAT
     DO 320 J=1,NP                                                     SHSTAT
     L=NPT(J)                                                          SHSTAT
     READ TAPE NT,(WF(K),K=1,45)                                       SHSTAT
     READ TAPE NT,((NS(M,K),M=1,6),K=1,L)                              SHSTAT
     IF(KPTO)156,157,156                                               SHSTAT
 156 CALL FOSCALI     WF,TLE,N17,N18,N19,        N20,N21,N22,N23A,N23B, SHSTAT
    1N23C,N23D)
     GO TO 158
 157 CALL FOSPUT(NPG1,WF,TLE,N17,N18,N19,        N20,N21,N22,N23A,N23B, SHSTAT
    1N23C,N23D)                                                        SHSTAT
 158 CALL FMASH(WF(5),MR1,L6,L30,L12,LR)                               SHSTAT
     CALL FMASH(WF(5),MR2,L6,L24,L6,LR)                                SHSTAT
     MR1=MR1*10+MR2+1                                                  SHSTAT
     IF(MSTR-MR1)231,232,232                                           SHSTAT
 231 MSTR=MR1                                                          SHSTAT
 232 CALL FMASH(WF(6),MPV1,L6,L30,L12,LR)                              SHSTAT
     CALL FMASH(WF(6),MPV2,L6,L24,L6,LR)                               SHSTAT
     MPV1=MPV1*10+MPV2                                                 SHSTAT
     IF(MPV-MPV1)233,234,234                                           SHSTAT
 233 MPV=MPV1                                                          SHSTAT
 234 AR1=N17(1)                                                        SHSTAT
     AR1=AR1/100.                                                      SHSTAT
     AR2=N17(2)                                                        SHSTAT
     AR=AR1*AR2                                                        SHSTAT
     ART=ART+AR                                                        SHSTAT
     MAR=LOG10F(AR )+1.                                                SHSTAT
     IF(MAR)235,235,236                                                SHSTAT
 235 MAR=1                                                             SHSTAT
     GO TO 238                                                         SHSTAT
 236 IF(MAR-5)238,238,237                                              SHSTAT
 237 MAR=5                                                             SHSTAT
 238 IF(KPTO)260,239,260
 239 NPG1=NPG1+1                                                       SHSTAT
     PRINT 5000,NPG1                                                   SHSTAT
     PRINT 5010,TLE(1),TLE(2),TLE(3),TLE(13),TLE(14),TLE(15)           SHSTAT
     PRINT 5020,TLE(16),TLE(17),TLE(19),TLE(18),TLE(20),TLE(4),(TLE(K), SHSTAT
    1K=5,12),TLE(23),TLE(24),TLE(22),TLE(21),N21                        SHSTAT
     PRINT 5030                                                        SHSTAT
 260 DO 310 K2=1,L                                                     SHSTAT
     CALL SHELT(NS(1,K2),NSH)                                          SHSTAT
     K4=NSH(8)                                                         SHSTAT
     IF(K4)310,310,1260
1260 IF(KPTO)1262,1261,1262                                            SHSTAT
1261 PRINT 5040,(NSH(K3),K3=1,13)                                      SHSTAT
1262 IF(NSH(1))310,262,262                                             SHSTAT
 262 NSH1=NSH(1)+1                                                     SHSTAT
     IFLP(NSH1,K4)=IFLP(NSH1,K4)+1                                     SHSTAT
     IF(NSH(1)-1)263,266,269                                           SHSTAT
 263 NB=N18(2)
```

```
      MHG=N23A(5)+N23A(6)+N23A(7)+N23A(   )                         SMSTAT
      MHB=(HBG/HF)*2.5+1.0                                              SMSTAT
      IF(10-MHB)1263,1264,1264
1263  MHB=10
1264  IBZ(MHB,K4)=IBZ(MHB,K4)+1                                         SMSTAT
      PSX=N23A(1)+N23A(2)+N23A(3)+N23A(4)                               SMSTAT
      NIPP=0                                                            SMSTAT
      DO 265 LJ=13,16                                                   SMSTAT
      IF(N23A(LJ))265,265,264                                           SMSTAT
 264  PSX1=N23A(LJ)                                                     SMSTAT
      PSX=PSX+PSX1                                                      SMSTAT
      MIPP=1                                                            SMSTAT
      NIPP=1                                                            SMSTAT
 265  CONTINUE                                                          SMSTAT
      APP=N23A(9)+N23A(10)+N23A(11)+N23A(12)                            SMSTAT
      GO TO 282                                                         SMSTAT
 266  NIPP=0                                                            SMSTAT
      PSX=N23B(1)+N23B(2)+N23B(3)+N23B(4)                               SMSTAT
      DO 268 LJ=9,12                                                    SMSTAT
      IF(N23B(LJ))268,268,267                                           SMSTAT
 267  PSX1=N23B(LJ)                                                     SMSTAT
      PSX=PSX+PSX1                                                      SMSTAT
      NIPP=1                                                            SMSTAT
      MIPP=1                                                            SMSTAT
 268  CONTINUE                                                          SMSTAT
      APP=N23B(5)+N23B(6)+N23B(7)+N23B(8)                               SMSTAT
      GO TO 275                                                         SMSTAT
 269  NIPP=0                                                            SMSTAT
      NPSX=0                                                            SMSTAT
      NAPP=0                                                            SMSTAT
      DO 274 LJ=1,4                                                     SMSTAT
      IF(N23D(LJ))270,270,1270                                          SMSTAT
1270  IF(NSH(1)-N23D(LJ))270,272,272                                    SMSTAT
 270  NPSX=NPSX+N23C(LJ)                                                SMSTAT
      NAPP=NAPP+N23C(LJ+4)                                              SMSTAT
      IF(N23C(LJ+8))274,274,271                                         SMSTAT
 271  NPSX=NPSX+N23C(LJ+8)
      MIPP=1
      MIPP=1                                                            SMSTAT
      GO TO 274                                                         SMSTAT
 272  NPSX=NPSX+N23E(LJ+4)                                              SMSTAT
      NAPP=NAPP+N23E(LJ+8)                                              SMSTAT
      IF(N23E(LJ+12))274,274,273                                        SMSTAT
 273  NPSX=NPSX+N23E(LJ+12)                                             SMSTAT
      NIPP=1                                                            SMSTAT
      MIPP=1                                                            SMSTAT
 274  CONTINUE                                                          SMSTAT
      PSX=NPSX                                                          SMSTAT
      APP=NAPP                                                          SMSTAT
      GO TO 277                                                         SMSTAT
 275  DO 276 LJ=1,4                                                     SMSTAT
 276  MHT(LJ)=N23A(LJ+4)                                                SMSTAT
      GO TO 279                                                         SMSTAT
 277  DO 278 LJ=1,4                                                     SMSTAT
 278  MHT(LJ)=N23B(LJ+4)+N18(3)+(NSH(1)-2)*N18(4)                       SMSTAT
 279  MPLT=0                                                            SMSTAT
      DO 281 LJ=1,4                                                     SMSTAT
      MPL=0                                                             SMSTAT
      DO 280 LK=1,3                                                     SMSTAT
      K7=LJ+8*(LK-1)                                                    SMSTAT
      IF(MHT(LJ)-N20(K7))281,280,280
```

```
  280 MPL=MPL+N20(K7+4)                                   SMSTAT
  281 MPLT=MPLT+MPL                                       SMSTAT
      PLNT=MPLT                                           SMSTAT
      MPLT=(PLNT/12 .)+1.                                 SMSTAT
      IPLP(MPLT,K4)=IPLP(MPLT,K4)+1                       SMSTAT
  282 IF(NIPP)284,284,283                                 SMSTAT
  283 IIP(K4)=IIP(K4)+1                                   SMSTAT
  284 MAPP=(APP/40.)+1.
      MPSX=(PSX/10 .)+1.                                  SMSTAT
      IAPP(MAPP,K4)=IAPP(MAPP,K4)+1                       SMSTAT
      IF(MPSX-20)286,286,285
  285 MPSX=20
  286 IPSP(MPSX,K4)=IPSP(MPSX,K4)+1                       SMSTAT
  287 IARP(MAR,K4)=IARP(MAR,K4)+1                         SMSTAT
      MND=1                                               SMSTAT
      NUT=0
      DO 1288 K5=2,6
 1288 NUT=NUT+NSH(K5)
      TOT=NUT
      DO 289 K5=2,5                                       SMSTAT
      CONT=NSH(K5)                                        SMSTAT
      CONT=CONT/TOT                                       SMSTAT
      IF(.4-CONT)288,288,289                              SMSTAT
  288 MND=MND+1                                           SMSTAT
  289 CONTINUE                                            SMSTAT
      CONT=NSH(6)                                         SMSTAT
      CONT=CONT/TOT                                       SMSTAT
      IF(.4-CONT)290,290,291                              SMSTAT
  290 MND=MND+3                                           SMSTAT
  291 IDZP(MND,K4)=IDZP(MND,K4)+1                         SMSTAT
  310 CONTINUE                                            SMSTAT
      IF(N18(2))313,313,311                               SMSTAT
  311 NSTR=NSTR+4                                         SMSTAT
      DO 312 LJ=1,4                                       SMSTAT
      MAP=MAP+N23A(LJ+8)                                  SMSTAT
  312 MPS=MPS+N23A(LJ)+N23A(LJ+12)                        SMSTAT
  313 NSTR=NSTR+4*(MR1-1)
      IF(MR1-1)320,320,314
  314 DO 315 LJ=1,4                                       SMSTAT
      MAP=MAP+N23B(LJ+4)                                  SMSTAT
  315 MPS=MPS+N23B(LJ+8)+N23B(LJ)                         SMSTAT
      NFL1=MR1-1
      IF(NFL1-1)320,320,316                               SMSTAT
  316 DO1320 LI=2,NFL1                                    SMSTAT
      DO1320 LJ=1,4                                       SMSTAT
      IF(N23D(LJ))318,318,317                             SMSTAT
  317 IF(N23D(LJ)-LI)319,319,318                          SMSTAT
  318 MAP=MAP+N23C(LJ+4)                                  SMSTAT
      MPS=MPS+N23C(LJ)+N23C(LJ+8)                         SMSTAT
      GO TO1320                                           SMSTAT
  319 MAP=MAP+N23D(LJ+8)                                  SMSTAT
      MPS=MPS+N23D(LJ+4)+N23D(LJ+12)                      SMSTAT
 1320 CONTINUE                                            SMSTAT
  320 CONTINUE                                            SMSTAT
      STRN=NSTR                                           SMSTAT
      APM=MAP                                             SMSTAT
      PSM=MPS                                             SMSTAT
      MAP=(APM/(STRN*10.))+1.0
      MPS=((PSM/STRN)/2.5)+1.0                            SMSTAT
      JAPP(MAP,MPF)=JAPP(MAP,MPF)+1                       SMSTAT
```

```
      INPT(NP,MPF)=INPT(NP,MPF)+1
      IF(MIPP)922,922,321                                               SHSTAT
  321 JIP(MPF)=JIP(MPF)+1                                               SHSTAT
  922 JFLP(MSTR,MPF)=JFLP(MSTR,MPF)+1                                   SHSTAT
      MAR=LOG10F(ART)+1.                                                SHSTAT
      IF(MAR)322,322,323                                                SHSTAT
  322 MAR=1                                                             SHSTAT
      GO TO 325                                                         SHSTAT
  323 IF(MAR-5)325,325,324                                              SHSTAT
  324 MAR=5                                                             SHSTAT
  325 JARP(MAR,MPF)=JARP(MAR,MPF)+1                                     SHSTAT
      JPV(MPV,MPF)=JPV(MPV,MPF)+1
      IF(MPS-20)327,327,326
  326 MPS=20                                                            SHSTAT
  327 JPSP(MPS,MPF)=JPSP(MPS,MPF)+1                                     SHSTAT
  330 CONTINUE
      PRINT 1200,MPF,NB                                                 SHSTAT
      CALL STAPUT(        IFLP,IAPP,IIP,IPLP,IARP,IPSP,IDZP)            SHSTAT
      DO 345 J=1,5                                                      HSTAT
      IIPT(J)=IIPT(J)+IIP(J)                                            SHSTAT
      DO 340 I=1,45                                                     SHSTAT
  340 IFL(I,J)=IFL(I,J)+IFLP(I,J)                                       SHSTAT
      DO 342 I=1,10                                                     SHSTAT
  342 IAP(I,J)=IAP(I,J)+IAPP(I,J)                                       SHSTAT
      DO 343 I=1,100                                                    SHSTAT
  343 IPL(I,J)=IPL(I,J)+IPLP(I,J)                                       SHSTAT
      DO 344 I=1,5                                                      SHSTAT
      IAR(I,J)=IAR(I,J)+IARP(I,J)                                       SHSTAT
  344 IDZ(I,J)=IDZ(I,J)+IDZP(I,J)
      DO 345 I=1,20                                                     SHSTAT
  345 IPS(I,J)=IPS(I,J)+IPSP(I,J)                                       SHSTAT
  350 CONTINUE
      IF(NBLD1)360,360,351                                              SHSTAT
  351 NBLD=NBLD1                                                        SHSTAT
      NTS1=NTS                                                          SHSTAT
      NTS=NTT                                                           SHSTAT
      NTT=NTS1                                                          SHSTAT
      MP=MP+2
      IF(MP-8)110,360,360                                               SHSTAT
  360 CALL FINPUT(MSUB,IFL,JFLP,          IAP,JAPP,     IIPT,JIP,       SHSTAT
     1 IPL,       IAR,JARP,          JPV,     IPS,JPSP,          IDZ,IBZ,
     2 INPT)                                                            SHSTAT
      CALL ENDJOB
 1000 FORMAT(2I10)
 1100 FORMAT(1H1,2X,43HTHE FOLLOWING SHELTER OUTPUT AND STATISTICS/10X,4 SHSTAT
     14HARE FOR BUILDINGS WHICH CONTAIN AT LEAST ONE/10X,16HSHELTER WITH SHSTAT
     2 PF=12,32H BUT NO SHELTER WITH A HIGHER PF)                       SHSTAT
 1200 FORMAT(1H1,30X,59HSHELTER STATISTICS FOR BUILDINGS WHICH CONTAIN A
     1T LEAST ONE/31X,16HSHELTER WIT  PF=12,33H BUT NO SHELTER WITH A HI
     2GHER PF./31X,10HTHERE ARE I4,2-H BUILDINGS IN THIS CATEGORY.)
 5000 FORMAT(1H1,109X,5HPAGE I5)
 5010 FORMAT(4HOSL=A4,1H-,2A2,5H  FD=A2,4H  C=A2,6H  FAC=A5)
 5020 FORMAT(1HO,6X,3HPT=2A1,4H OF A2,6H  REV=A1,4H ST=A2,4X,A2,PA6,6H
     1USE=A2,5H OWN=A1,4H PV=A2,6H YEAR=A4,4H SP=I1)
 5030 FORMAT(45X,75HSTORY  A    B   C    .    CL   TOT   PF   FLOOR    S-AREA
     1 CORE    VOLUME    PEOPLE)
 5040 FORMAT(46X,6I4,I5,I4,3I8,I9,I7)
      END
```

```
      SUBROUTINE STAPUT(       IFLP,IAPP,IIP,IPLP,IARP,IPSP,IDZP)          STAPUT
      DIMENSION IFLP(45,8),IAPP(10,8),IIP(8),IPLP(100,8),IARP(5,8),        STAPUT
     1IPSP(20,8),IDZP(5,8),NFL(45),NAP(10),NPL(100),NAR(5),        NDZ(5)  STAPUT
     2,TOT(9),JTO(8),JTOI(8),NPS(20)                                        STAPUT
     3,AFL(45),SFL(45),AAP(10), SAP(10),APL(100),SPL(100),AAR(5), SAR(5)
     4,ADZ(5),SDZ(5),APS(20),        FFL(9),TFL(9),PAP(9),TAP(9),RPL(9),
     5 TPL(9),RAR(9),TAR(9),RDZ(9),TDZ(9),RPS(9),TPS(9),SPS(20)
      DO 50 I=1,9
      RFL(I)=0.
      TFL(I)=0.
      RAP(I)=0.
      TAP(I)=0.
      RAR(I)=0.
      TAR(I)=0.
      RPS(I)=0.
      RDZ(I)=0.
      TDZ(I)=0.
      RPL(I)=0.
      TPL(I)=0.
   50 TPS(I)=0.
      CALL  SETUP(45,MFL,NFL,IFLP,AFL,SFL)
      CALL  SETUP(10,MAP,NAP,IAPP,AAP,SAP)
      CALL  SETUP(100,MPL,NPL,IPLP,APL,SPL)
      CALL  SETUP(5,MAR,NAR,IAPP,AAR,SAR)
      CALL  SETUP(1,NIP,FIP,IIP,AIP,SIP)
      CALL  SETUP(20,MPS,NPS,IPSP,APS,SPS)
      CALL  SETUP(5,MDZ,NDZ,IDZP,ADZ,SDZ)                                  STAPUT
      J=1                                                                  STAPUT
      IF(MFL-MAP)146,147,146                                               STAPUT
  146 PRINT 2500,J,MFL,MAP                                                 STAPUT
  147 J=2                                                                  STAPUT
      IF(MAP-MAR)148,149,148                                               STAPUT
  148 PRINT 2500,J,MAP,MAR                                                 STAPUT
  149 J=3                                                                  STAPUT
      IF(MAR-MDZ)1150,1151,1150                                            STAPUT
 1150 PRINT 2500,J,MAR,MDZ                                                 STAPUT
 1151 J=4                                                                  STAPUT
      IF(MDZ-MPS)1152,1153,1152                                            STAPUT
 1152 PRINT 2500,J,MDZ,MPS                                                 STAPUT
 1153 SHT1=MFL                                                             STAPUT
      SHT2=MPL                                                             STAPUT
      DO 1155 I=1,8                                                        STAPUT
      JTO(I)=0                                                             STAPUT
      JTOI(I)=0                                                            STAPUT
      DO 1154 J=1,45                                                       STAPUT
 1154 JTO(I)=JTO(I)+IFLP(J,I)                                              STAPUT
      DO 1155 J=1,100                                                      STAPUT
 1155 JTOI(I)=JTOI(I)+IPLP(J,I)                                            STAPUT
      PRINT 2000                                                           STAPUT
      PRINT 1100                                                           STAPUT
      PRINT 1500
      PRINT 4700                                                           STAPUT
      PRINT 1400                                                           STAPUT
      DO 150 K=1,45                                                        STAPUT
      K=K-1
```

```
      CALL GOOL(I,45,K,IFLP,NFL(I),BFL,TFL)                        STAPUT
150   PRINT 1300,K,(IFLP(I,J),J=1,8),NFL(I),AFL(I),SFL(I)          STAPUT
      PRINT 3100,(JTO(I),I=1,8)
      CALL TOOL(JTO,MFL,BFL,TFL)                                   STAPUT
      PRINT 2000                                                   STAPUT
      PRINT 2600                                                   STAPUT
      PRINT 1500                                                   STAPUT
      PRINT 1200                                                   STAPUT
      PRINT 1400                                                   STAPUT
      DO 155 I=1,45                                                STAPUT
      K=I-1                                                        STAPUT
      DO 154 J=1,8                                                 STAPUT
      TOT(J)=IFLP(I,J)                                             STAPUT
154   TOT(J)=TOT(J)/SHT1                                           STAPUT
      TOT(9)=NFL(I)                                                STAPUT
      TOT(9)=TOT(9)/SHT1                                           STAPUT
155   PRINT 2700,K,(TOT(J),J=1,9)                                  STAPUT
      DO 156 I=1,8                                                 STAPUT
      TOT(I)=JTO(I)                                                STAPUT
156   TOT(I)=TOT(I)/SHT1                                           STAPUT
      PRINT 3200,(TOT(I),I=1,8)
      PRINT 2000                                                   STAPUT
      PRINT 1100                                                   STAPUT
      PRINT 1600
      PRINT 4700                                                   STAPUT
      PRINT 1400                                                   STAPUT
      DO 160 I=1,10
      K=(I-1)*10
      CALL COOL(I,10,K,IAPP,NAP(I),RAP,TAP,10)                     STAPUT
      PRINT 1400                                                   STAPUT
160   PRINT 1300,K,(IAPP(I,J),J=1,8),NAP(I),AAP(I),SAP(I)
      PRINT 1400
      CALL TOOL(JTO,MFL,RAP,TAP)
      PRINT 2000                                                   STAPUT
      PRINT 2600                                                   STAPUT
      PRINT 1600                                                   STAPUT
      PRINT 1200                                                   STAPUT
      PRINT 1400                                                   STAPUT
      DO 165 I=1,10
      K=(I-1)*10                                                   STAPUT
      DO 164 J=1,8                                                 STAPUT
      TOT(J)=IAPP(I,J)                                             STAPUT
164   TOT(J)=TOT(J)/SHT1                                           STAPUT
      TOT(9)=NAP(I)                                                STAPUT
      TOT(9)=TOT(9)/SHT1                                           STAPUT
      PRINT 1400                                                   STAPUT
165   PRINT 2700,K,(TOT(J),J=1,9)                                  STAPUT
      DO 170 L=1,2                                                 STAPUT
      PRINT 2000                                                   STAPUT
      PRINT 1100                                                   STAPUT
      PRINT 1700
      PRINT 4700                                                   STAPUT
      PRINT 1400                                                   STAPUT
      DO 170 I=1,50                                                STAPUT
      K=(I-1)*30+(L-1)*1500
```

```
      N=I+50*(L-1)                                                      STAPUT
      CALL COOL(N,100,K,IPLP,NPL (N),BPL,TPL,30)
  170 PRINT 1300,K,(IPLP(N,J),J=1,8),NPL(N),APL(N),SPL(N)               STAPUT
      PRINT 3100,(JTOT(I),I=1,8)                                        STAPUT
      CALL TOOL(JTOT,MPL,BPL,TPL)
      DO 175 L=1,2                                                      STAPUT
      PRINT 2000                                                        STAPUT
      PRINT 2600                                                        STAPUT
      PRINT 1700                                                        STAPUT
      PRINT 1200                                                        STAPUT
      PRINT 1400                                                        STAPUT
      DO 175 I=1,50                                                     STAPUT
      K=(I-1)*30+(L-1)*1500
      N=I+50*(L-1)                                                      STAPUT
      DO 174 J=1,8                                                      STAPUT
      TOT(J)=IPLP(N,J)                                                  STAPUT
  174 TOT(J)=TOT(J)/SHT2                                                STAPUT
      TOT(9)=NPL(N)                                                     STAPUT
      TOT(9)=TOT(9)/SHT2                                                STAPUT
  175 PRINT 2700,K,(TOT(J),J=1,9)                                       STAPUT
      DO 176 I=1,8                                                      STAPUT
      TOT(I)=JTOT(I)                                                    STAPUT
  176 TOT(I)=TOT(I)/SHT2                                                STAPUT
      PRINT 3200,(TOT(I),I=1,8)                                         STAPUT
      PRINT 2000                                                        STAPUT
      PRINT 1100                                                        STAPUT
      PRINT 1800                                                        STAPUT
      PRINT 4700
      PRINT 1400                                                        STAPUT
      DO 180 I=1,5                                                      STAPUT
      K=I+1                                                             STAPUT
      CALL COOL(I,5,K,IARP,NAR(I),BAR,TAR,1)
      PRINT 1400                                                        STAPUT
  180 PRINT 1300,K,(IARP(I,J),J=1,8),NAR(I),AAR(I),SAR(I)               STAPUT
      PRINT 1400
      CALL TOOL(JTO,MFL,BAR,TAR)
      PRINT 2000                                                        STAPUT
      PRINT 2600                                                        STAPUT
      PRINT 1800                                                        STAPUT
      PRINT 1200                                                        STAPUT
      PRINT 1400                                                        STAPUT
      DO 185 I=1,5                                                      STAPUT
      K=I+1                                                             STAPUT
      DO 184 J=1,8                                                      STAPUT
      TOT(J)=IARP(I,J)                                                  STAPUT
  184 TOT(J)=TOT(J)/SHT1                                                STAPUT
      TOT(9)=NAR(I)                                                     STAPUT
      TOT(9)=TOT(9)/SHT1                                                STAPUT
      PRINT 1400                                                        STAPUT
  185 PRINT 2700,K,(TOT(J),J=1,9)                                       STAPUT
      PRINT 1900                                                        STAPUT
      PRINT 1100                                                        STAPUT
      PRINT 1400                                                        STAPUT
      PRINT 4700
      PRINT 1400                                                        STAPUT
```

```
      PRINT 2400,(IIP(I),I=1,6),NIP,AIP,SIP                          STAPUT
      DO 186 I=1,8                                                    STAPUT
      TOT(I)=IIP(I)                                                   STAPUT
186   TOT(I)=TOT(I)/SHT1                                              STAPUT
      TOT(9)=NIP                                                      STAPUT
      TOT(9)=TOT(9)/SHT1                                              STAPUT
      PRINT 2900                                                      STAPUT
      PRINT 2600                                                      STAPUT
      PRINT 1400                                                      STAPUT
      PRINT 1200                                                      STAPUT
      PRINT 1400                                                      STAPUT
      PRINT 2800,(TOT(I),I=1,9)                                       STAPUT
      PRINT 2000                                                      STAPUT
      PRINT 1100                                                      STAPUT
      PRINT 2100                                                      STAPUT
      PRINT 4700
      PRINT 1400                                                      STAPUT
      DO 190 I=1,20                                                   STAPUT
      K=(I-1)*25                                                      STAPUT
      CALL COOL(I,20,K,IPSP,NPS(I),BPS,TPS,25)
      PRINT 1499                                                      STAPUT
190   PRINT 1300,K,(IPSP(I,J),J=1,8),NPS(I),APS(I),SPS(I)             STAPUT
      PRINT 1400
      CALL TOOL(JTO,MFL,BPS,TPS)
      PRINT 2000                                                      STAPUT
      PRINT 2600                                                      STAPUT
      PRINT 2100                                                      STAPUT
      PRINT 1200                                                      STAPUT
      PRINT 1400                                                      STAPUT
      DO 195 I=1,20                                                   STAPUT
      K=(I-1)*25                                                      STAPUT
      DO 194 J=1,8                                                    STAPUT
      TOT(J)=IPSP(I,J)                                                STAPUT
194   TOT(J)=TOT(J)/SHT1                                              STAPUT
      TOT(9)=NPS(I)                                                   STAPUT
      TOT(9)=TOT(9)/SHT1                                              STAPUT
      PRINT 1400                                                      STAPUT
195   PRINT 2700,K,(TOT(J),J=1,9)                                     STAPUT
      PRINT 2300                                                      STAPUT
      PRINT 1100                                                      STAPUT
      PRINT 2200                                                      STAPUT
      PRINT 4700
      PRINT 1400                                                      STAPUT
      DO 200 I=1,5                                                    STAPUT
      CALL GOOL(I,5,1,IDZP,NDZ(I),BDZ,TDZ)
      PRINT 1400                                                      STAPUT
200   PRINT 1300,I,(IDZP(I,J),J=1,8),NDZ(I),ADZ(I),SDZ(I)
      PRINT 1400
      CALL TOOL(JTO,MFL,BDZ,TDZ)
      PRINT 3000                                                      STAPUT
      PRINT 2600                                                      STAPUT
      PRINT 2200                                                      STAPUT
      PRINT 1200                                                      STAPUT
      PRINT 1400                                                      STAPUT
      DO 210 I=1,5                                                    STAPUT
```

```
      DO 205 J=1,8                                                            STAPUT
      TOT(J)=IDZP(I,J)                                                        STAPUT
  205 TOT(J)=TOT(J)/SHT1                                                      STAPUT
      TOT(9)=NDZ(I)                                                           STAPUT
      TOT(9)=TOT(9)/SHT1                                                      STAPUT
      PRINT 1400                                                              STAPUT
  210 PRINT 2700,I,(TOT(J),J=1,9)                                             STAPUT
      RETURN                                                                  STAPUT
 1100 FORMAT     (31X,34HNUMBER OF SHELTERS PER PF CATEGORY)                  STAPUT
 1200 FORMAT(23X,1H1,6X,1H2,6X,1H3,6X,1H4,6X,1H5,6X,1H6,6X,1H7,6X,1H8,8H STAPUT
     1   TOTAL)                                                               STAPUT
 1300 FORMAT(11X,I4,3X,9I7,2F7.2)
 1400 FORMAT(1H )                                                             STAPUT
 1500 FORMAT(11X,5HSTORY/11X,6HNUMBER)                                        STAPUT
 1600 FORMAT(10X,7HPERCENT/10X,8HAPERTURE)                                    STAPUT
 1700 FORMAT(10X,7HCONTAM./10X,5HPLANE/10X,5HWIDTH)                           STAPUT
 1800 FORMAT(12X,4H LOG/12X,5HFLOOR/12X,4HAREA)                               STAPUT
 1900 FORMAT(1H1,29X,33HSHELTERS WITH INTERIOR PARTITIONS////)
 2000 FORMAT(1H1)                                                             STAPUT
 2100 FORMAT(12X,3HPSF)                                                       STAPUT
 2200 FORMAT(14X,1HI)                                                         STAPUT
 2300 FORMAT(1H1,39X,11HDOSE SOURCE//25X,49HI=1  NO SINGLE CONTRIBUTION  STAPUT
     140 PERCENT OR GREATER/25X,47HI=2  ONE WALL CONTRIBUTES 40 PERCENT  STAPUT
     2OR GREATER/25X,47HI=3  TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER/ STAPUT
     325X,46HI=4  CEILING CONTRIBUTES 40 PERCENT OR GREATER/25X,58HI=5   STAPUT
     4CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER/)                 STAPUT
 2400 FORMAT(18X,9I7,2F7.2)
 2500 FORMAT(1H1,9X,31HSHELTER COUNTS DO NOT CHECK FOR3I10)                   STAPUT
 2600 FORMAT(29X,36HFRACTION OF SHELTERS PER PF CATEGORY)
 2700 FORMAT(11X,I4,3X,9F7.4)                                                 STAPUT
 2800 FORMAT(18X,9F7.4)                                                       STAPUT
 2900 FORMAT(1H7)                                                             STAPUT
 3000 FORMAT(1H8)                                                             STAPUT
 3100 FORMAT(10X,5HTOTAL,3X,8I7)                                              STAPUT
 3200 FORMAT(10X,5HTOTAL,3X,8F7.4)                                            STAPUT
 4700 FORMAT(23X,1H1,6X,1H2,6X,1H3,6X,1H4,6X,1H5,6X,1H6,6X,1H7,6X,1H8,8H STAPUT
     1   TOTAL,14H  AV PF     S D)                                            STAPUT
      END
```

```
      SUBROUTINE FINPUT(MSUB,IFL,JFLP,          IAP,JAPP,     IIPT,JIP,  FINPUT
     1      IPL,     IAP,JARP,            JPV,     IPS,JPSP,          IDZ  FINPUT
     2,IBZ,     INPT)
      DIMENSION            IFL(45,8),JFLP(45,8),JFLT(45),            IAP(10,8 FINPUT
     1),JAPP(10,8),JAPT(10),IIPT(8),JIP(8),                IPL(100,8),    FINPUT
     2 IAR(5,8),JARP(5,8),JART(5),JPVT(9)),JPV(9),8),           IPS(20,8),  FINPUT
     3 IPSP(20,8),JPSP(20,8),JPST(20),        IBZ(10,8),IBZT(9 ,INPT(20,8), FINPUT
     4 INPTT(20),TOT(9),IPV(33),NBZ(10),NNPT(8),                 IDZ(5,8)  FINPUT
     5,AFL(45),SFL(45),AAP(10),SAP(10),AAR(5),SAR(5),APV(9)),SPV(9)),
     6 APS(20),        ABZ(10),SBZ(10),ANP(20),SNP(20), SPS(20),
     7 BFL(9),TFL(9),BAP(9),TAP(9),BAR(9),TAR(9),BPV(9),TPV(9),BPS(9),
     8  TPS(9),BBZ(9),TBZ(9),BNP(9),TNP(9)
      DO 50 I=1,9
      BFL(I)=0.
      TFL(I)=0.
      BAP(I)=0.
      TAP(I)=0.
      BAR(I)=0.
      TAR(I)=0.
      BPS(I)=0.
      TPS(I)=0.
      BPV(I)=0.
      TPV(I)=0.
      BBZ(I)=0.
      TBZ(I)=0.
      BNP(I)=0.
   50 TNP(I)=0.                                                          FINPUT
      MPS=0
      CALL  SETUP(45,NFL,JFLT,JFLP,AFL,SFL)
      CALL  SETUP(10,NAP,JAPT,JAPP,AAP,SAP)
      CALL  SETUP(5,NAR,JART,JARP,AAR,SAR)
      CALL  SETUP(9),NPV,JPVT,JPV,APV,SPV)
      CALL  SETUP(20,NPS,JPST,JPSP,APS,SPS)
      CALL  SETUP(10,MBZ,NBZ,IBZ,ABZ,SSZ)
      CALL  SETUP(1,NIP,KIP,JIP,AIP,SIP)
      CALL  SETUP(20,MNP,INPTT,INPT,ANP,SNP)
      DO 120 I=1,5
      DO 120 J=1,8
  120 MPS=MPS+IAR(I,J)
      DO 130 I=1,8
      IBZT(I)=0
      DO 130 J=1,10
  130 IBZT(I)=IBZT(I)+IBZ(J,I)                                           FINPUT
      DO 630 I=1,8                                                       FINPUT
      NNPT(I)=0                                                          FINPUT
      DO 630 J=1,20                                                      FINPUT
  630 NNPT(I)=NNPT(I)+INPT(J,I)                                          FINPUT
  240 J=1                                                                FINPUT
      IF(NFL-NAP)250,260,250                                             FINPUT
  250 PRINT 3600,J,NFL,NAP                                               FINPUT
  260 J=2                                                                FINPUT
      IF(NAP-NAR)270,280,270                                             FINPUT
  270 PRINT 3600,J,NAP,NAR                                               FINPUT
  280 J=3                                                                FINPUT
      IF(NAR-NPV)290,300,290
```

```
290 PRINT 3600,J,NAR,NPV                                          FINPUT
300 J=4                                                           FINPUT
    IF(NPV-NPS)310,320,310                                        FINPUT
310 PRINT 3600,J,NPV,NPS                                          FINPUT
320 PRINT 1000,NPS,MPS                                            FINPUT
    CALL STAPUT(IFL,IAP,IIP T,IPL,IAR,IPS,IPT)
    RLT =NPS                                                      FINPUT
    PRINT 2000                                                    FINPUT
    PRINT 3100                                                    FINPUT
    PRINT 1500                                                    FINPUT
    PRINT 4700
    PRINT 1400                                                    FINPUT
    DO 460 I=1,45                                                 FINPUT
    K=I-1                                                         FINPUT
    CALL GOOL(I,45,K,JFLP,JFLT(I),PFL,TFL)
460 PRINT 1300,K,(JFLP(I,J),J=1,8),JFLT(I),PFL(I),TFL(I)          FINPUT
    CALL TOOL(NNPT,MNP,PFL,TFL)
    PRINT 2000                                                    FINPUT
    PRINT 3900                                                    FINPUT
    PRINT 1500                                                    FINPUT
    PRINT 1200                                                    FINPUT
    PRINT 1400                                                    FINPUT
    DO 470 I=1,45                                                 FINPUT
    K=I-1                                                         FINPUT
    DO 465 J=1,8                                                  FINPUT
    TOT(J)=JFLP(I,J)                                              FINPUT
465 TOT(J)=TOT(J)/RLT                                             FINPUT
    TOT(9)=JFLT(I)                                                FINPUT
    TOT(9)=TOT(9)/RLT                                             FINPUT
470 PRINT 2700,K,(TOT(J),J=1,9)                                   FINPUT
    PRINT 2000
    PRINT 3100                                                    FINPUT
    PRINT 1600                                                    FINPUT
    PRINT 4700
    PRINT 1400                                                    FINPUT
    DO 480 I=1,10                                                 FINPUT
    K=(I-1)*10
    CALL COOL(I,10,K,JAPP,JAPT(I),PAF,TAP,I)
    PRINT 1400                                                    FINPUT
480 PRINT 1300,K,(JAPP(I,J),J=1,8),JAPT(I),PAP(I),TAP(I)          FINPUT
    PRINT 1400
    CALL TOOL(NNPT,MNP,PAF,TAP)
    PRINT 2000                                                    FINPUT
    PRINT 3900                                                    FINPUT
    PRINT 1600                                                    FINPUT
    PRINT 1200                                                    FINPUT
    PRINT 1400                                                    FINPUT
    DO 490 I=1,10
    K=(I-1)*10                                                    FINPUT
    DO 485 J=1,8                                                  FINPUT
    TOT(J)=JAPP(I,J)                                              FINPUT
485 TOT(J)=TOT(J)/RLT                                             FINPUT
    TOT(9)=JAPT(I)                                                FINPUT
    TOT(9)=TOT(9)/RLT                                             FINPUT
    PRINT 1400
```

```
490 PRINT 2700,K,(TOT(J),J=1,9)                                         FINPUT
    PRINT 1900                                                          FINPUT
    PRINT 3100                                                          FINPUT
    PRINT 1400                                                          FINPUT
    PRINT 4700                                                          FINPUT
    PRINT 1400                                                          FINPUT
    PRINT 2400,(JIP(I),I=1,8),NIP,AI                                    FINPUT
    DO 500 I=1,8                                                        FINPUT
    TOT(I)=JIP(I)                                                       FINPUT
500 TOT(I)=TOT(I)/BLT                                                   FINPUT
    TOT(9)=NIP                                                          FINPUT
    TOT(9)=TOT(9)/BLT                                                   FINPUT
    PRINT 2900                                                          FINPUT
    PRINT 3900                                                          FINPUT
    PRINT 1400                                                          FINPUT
    PRINT 1200                                                          FINPUT
    PRINT 1400                                                          FINPUT
    PRINT 2800,(TOT(I),I=1,9)                                           FINPUT
    PRINT 2000                                                          FINPUT
    PRINT 3100                                                          FINPUT
    PRINT 1800
    PRINT 4700                                                          FINPUT
    PRINT 1400                                                          FINPUT
    DO 510 I=1,5                                                        FINPUT
    K=I+1
    CALL COOL(I,5,K,JARP,JART(I),BAR,TAR,1)                             FINPUT
    PRINT 1400
510 PRINT 1300,K,(JARP(I,J),J=1,8),JART(I),AAR(I),SAR(I)
    PRINT 1400
    CALL TOOL(NNPT,MNP,BAR,TAR)                                         FINPUT
    PRINT 2900                                                          FINPUT
    PRINT 3900                                                          FINPUT
    PRINT 1800                                                          FINPUT
    PRINT 1200                                                          FINPUT
    PRINT 1400                                                          FINPUT
    DO 520 I=1,5                                                        FINPUT
    K=I+1                                                               FINPUT
    DO 515 J=1,8                                                        FINPUT
    TOT(J)=JARP(I,J)                                                    FINPUT
515 TOT(J)=TOT(J)/BLT                                                   FINPUT
    TOT(9)=JART(I)                                                      FINPUT
    TOT(9)=TOT(9)/BLT                                                   FINPUT
    PRINT 1400                                                          FINPUT
520 PRINT 2700,K,(TOT(J),J=1,9)                                         FINPUT
    PRINT 2000                                                          FINPUT
    PRINT 3100                                                          FINPUT
    PRINT 2100
    PRINT 4700                                                          FINPUT
    PRINT 1400                                                          FINPUT
    DO 530 I=1,20
    K=(I-1)*25
    CALL COOL(I,20,K,JPSP,JPST(I),BPS,TPS,25)                           FINPUT
    PRINT 1400                                                          FINPUT
530 PRINT 1300,K,(JPSP(I,J),J=1,8),JPST(I),APS(I),SPS(I)
    PRINT 1400
```

```
      CALL TOOL(NNPT,MNP,BPS,TPS)
      PRINT 2000                                                        FINPUT
      PRINT 3900                                                        FINPUT
      PRINT 2100                                                        FINPUT
      PRINT 1200                                                        FINPUT
      PRINT 1400                                                        FINPUT
      DO 540 I=1,20
      K=(I-1)*25                                                        FINPUT
      DO 535 J=1,8                                                      FINPUT
      TOT(J)=JPSP(I,J)                                                  FINPUT
  535 TOT(J)=TOT(J)/BLT                                                 FINPUT
      TOT(9)=JPST(I)                                                    FINPUT
      TOT(9)=TOT(9)/BLT                                                 FINPUT
      PRINT 1400                                                        FINPUT
  540 PRINT 2700,K,(TOT(J),J=1,9)                                       FINPUT
      IPV(1)=11                                                         FINPUT
      IPV(2)=21                                                         FINPUT
      IPV(3)=22                                                         FINPUT
      IPV(4)=31                                                         FINPUT
      IPV(5)=32                                                         FINPUT
      IPV(6)=34                                                         FINPUT
      DO 550 I=7,10                                                     FINPUT
  550 IPV(I)=IPV(I-1)+1                                                 FINPUT
      IPV(11)=41                                                        FINPUT
      DO 560 I=12,19                                                    FINPUT
  560 IPV(I)=IPV(I-1)+1                                                 FINPUT
      IPV(20)=51                                                        FINPUT
      DO 570 I=21,28                                                    FINPUT
  570 IPV(I)=IPV(I-1)+1                                                 FINPUT
      IPV(29)=91                                                        FINPUT
      IPV(30)=61                                                        FINPUT
      IPV(31)=62                                                        FINPUT
      IPV(32)=71                                                        FINPUT
      IPV(33)=81                                                        FINPUT
      PRINT 2000                                                        FINPUT
      PRINT 3100                                                        FINPUT
      PRINT 4000
      PRINT 4700                                                        FINPUT
      PRINT 1400                                                        FINPUT
      DO 580 I=1,33                                                     FINPUT
      K=IPV(I)
      CALL GOOL(K,91,I,JPV,JPVT(K),BPV,TPV)                             FINPUT
  580 PRINT 1300,K,(JPV(K,J),J=1,8),JPVT(K),AFV(K),SPV(K)
      CALL TOOL(NNPT,MNP,BPV,TPV)                                       FINPUT
      PRINT 2000                                                        FINPUT
      PRINT 3900                                                        FINPUT
      PRINT 4000                                                        FINPUT
      PRINT 1200                                                        FINPUT
      PRINT 1400                                                        FINPUT
      DO 590 I=1,33                                                     FINPUT
      K=IPV(I)                                                          FINPUT
      DO 585 J=1,8                                                      FINPUT
      TOT(J)=JPV(K,J)                                                   FINPUT
  585 TOT(J)=TOT(J)/BLT                                                 FINPUT
      TOT(9)=JPVT(K)
```

```
      TOT(9)=TOT(9)/HLT                                                FINPUT
  590 PRINT 2700,K,(TOT(J),J=1,9)                                      FINPUT
      BZT=MBZ                                                          FINPUT
      PRINT 2000                                                       FINPUT
      PRINT 4100                                                       FINPUT
      PRINT 4300                                                       FINPUT
      PRINT 4700
      PRINT 1400                                                       FINPUT
      DO 600 I=1,10                                                    FINPUT
      K=(I-1)*10
      CALL COOL(I,10,K,IBZ,NBZ(I),HBZ,THZ,10)
      PRINT 1400                                                       FINPUT
  600 PRINT 1300,K,(IBZ(I,J),J=1,8),NBZ(I),ABZ(I),SBZ(I)
      PRINT 1400
      PRINT 4400,(IBZT(I),I=1,6)                                       FINPUT
      PRINT 1400
      CALL TOOL(IBZT,MBZ,BBZ,TBZ)
      PRINT 1400
      PRINT 4800,MSUB
      PRINT 2900                                                       FINPUT
      PRINT 4200                                                       FINPUT
      PRINT 4300                                                       FINPUT
      PRINT 1200                                                       FINPUT
      PRINT 1400                                                       FINPUT
      DO 610 I=1,10                                                    FINPUT
      K=(I-1)*10
      DO 605 J=1,8                                                     FINPUT
      TOT(J)=IBZ(I,J)
  605 TOT(J)=TOT(J)/BZT                                                FINPUT
      TOT(9)=NBZ(I)                                                    FINPUT
      TOT(9)=TOT(9)/BZT                                                FINPUT
      PRINT 1400                                                       FINPUT
  610 PRINT 2700,K,(TOT(J),J=1,9)                                      FINPUT
      DO 620 I=1,8                                                     FINPUT
      TOT(I)=IBZT(I)                                                   FINPUT
  620 TOT(I)=TOT(I)/BZT                                                FINPUT
      PRINT 1400                                                       FINPUT
      PRINT 4500,(TOT(J),J=1,8)                                        FINPUT
      PRINT 2000                                                       FINPUT
      PRINT 3100                                                       FINPUT
      PRINT 4600                                                       FINPUT
      PRINT 4700
      PRINT 1400                                                       FINPUT
      DO 640 I=1,20                                                    FINPUT
      CALL GOOL(I,20,I,INPT,INPTT(I),PNP,TNP)
      PRINT 1400                                                       FINPUT
  640 PRINT 1300,I,(INPT(I,J),J=1,8),INPTT(I),ANP(I),SNP(I)            FINPUT
      PRINT 1400                                                       FINPUT
      PRINT 4400,(NNPT(I),I=1,5)                                       FINPUT
      PRINT 1400
      CALL TOOL(NNPT,MNP,BNP,TNP)
      PRINT 2000                                                       FINPUT
      PRINT 3900                                                       FINPUT
      PRINT 4600                                                       FINPUT
      PRINT 1200                                                       FINPUT
```

```
      PRINT 1400                                                        FINPUT
      DO 650 I=1,20                                                     FINPUT
      DO 645 J=1,8                                                      FINPUT
      TOT(J)=INPT(I,J)                                                  FINPUT
  645 TOT(J)=TOT(J)/BLT                                                 FINPUT
      TOT(9)=INPTT(I)                                                   FINPUT
      TOT(9)=TOT(9)/BLT                                                 FINPUT
      PRINT 1400                                                        FINPUT
  650 PRINT 2700,I,(TOT(J),J=1,9)                                       FINPUT
      DO 660 I=1,8                                                      FINPUT
      TOT(I)=NNPT(I)                                                    FINPUT
  660 TOT(I)=TOT(I)/BLT                                                 FINPUT
      PRINT 1400                                                        FINPUT
      PRINT 4500,(TOT(I),I=1,9)                                         FINPUT
      RETURN                                                            FINPUT
 1000 FORMAT(1H1,30X,37HTOTAL SHELTER AND BUILDING STATISTICS//31X,17HTO FINPUT
     1TAL BUILDINGS =I5,19H.  TOTAL SHELTERS =I5,1H.)                   FINPUT
 1200 FORMAT(23X,1H1,6X,1H2,6X,1H3,6X,1H4,6X,1H5,6X,1H6,6X,1H7,6X,1H8,8H STAPUT
     1   TOTAL)                                                         STAPUT
 1300 FORMAT(11X,I4,3X,9I7,2F7.2)
 1400 FORMAT(1H )                                                       FINPUT
 1500 FORMAT(11X,5HSTORY/11X,6HNUMBER)
 1600 FORMAT(10X,7HPERCENT/10X,8HAPERTURE)                              STAPUT
 1800 FORMAT(12X,4H LOG/12X,5HFLOOR/12X,4HAREA)
 1900 FORMAT(1H1,29X,34HBUILDINGS WITH INTERIOR PARTITIONS////)
 2000 FORMAT(1H1)                                                       FINPUT
 2100 FORMAT(12X,3HPSF)                                                 STAPUT
 2400 FORMAT(18X,9I7,2F7.2)
 2600 FORMAT(29X,36HFRACTION OF SHELTERS PER PF CATEGORY)               FINPUT
 2700 FORMAT(11X,I4,3X,9F7.4)
 2800 FORMAT(18X,9F7.4)                                                 STAPUT
 2900 FORMAT(1H7)
 3100 FORMAT(31X,35HNUMBER OF BUILDINGS PER PF CATEGORY)                FINPUT
 3600 FORMAT(1H1,9X,32HBUILDING COUNTS DO NOT CHECK FOR3I10)            FINPUT
 3700 FORMAT(11X,I4,59X,I7)                                             FINPUT
 3800 FORMAT(11X,I4,59X,F7.4)                                           FINPUT
 3900 FORMAT(29X,37HFRACTION OF BUILDINGS PER PF CATEGORY)              FINPUT
 4000 FORMAT(13X,2HPV)                                                  FINPUT
 4100 FORMAT(31X, 35HNUMBER OF BASEMENTS PER PF CATEGORY)               FINPUT
 4200 FORMAT(31X,37HFRACTION OF BASEMENTS PER PF CATEGORY)              FINPUT
 4300 FORMAT(10X,7HPERCENT/10X,8HEXPOSURE)                              FINPUT
 4400 FORMAT(10X,5HTOTAL,3X,8I7)                                        FINPUT
 4500 FORMAT(10X,5HTOTAL,3X,8F7.4)                                      FINPUT
 4600 FORMAT(7X,8HBUILDING/10X,5HPARTS)                                 FINPUT
 4700 FORMAT(23X,1H1,6X,1H2,6X,1H3,6X,1H4,6X,1H5,6X,1H6,6X,1H7,6X,1H8,5H
     1   TOTAL,14H  AV PF     S.D)                                      STAPUT
 4800 FORMAT(1H0,20X,31HTOTAL NUMBER OF SUBBASEMENTS I5(5)              FINPUT
      END
```

```
      SUBROUTINE FOSPUT(NPG1,WF,TLE,N17,N18,N19,N20,N21,N22,N23A,N23B,
     1 N23C,N23D)
      DIMENSION WF(45),TLE(27),N17(7),N18(4),N19(19),N20(24),N22(4),
     1 N23A(16),N23B(12),N23C(12),N23D(16)
      CALL FO1T16(WF,TLE)
      CALL FO17(WF,N17)
      CALL FO18(WF,N18)
      CALL FO19(WF,N19)
      CALL FO20(WF,N20)
      CALL FO21(WF,N21)
      CALL FO22(WF,N22)
      CALL FO23A(WF,N23A)
      CALL FO23B(WF,N23B)
      CALL FO23C(WF,N23C)
      CALL FO23D(WF,N23D)
      NPG1=NPG1+1
      PRINT                  5000,NPG1
      PRINT                  6000,TLE(27),(TLE(J),J=4,12),(TLE(J),J=1,3),
     1(TLE(J),J=13,26)
      PRINT                  6010,N17(1),N17(2),N18(1),N17(3),N17(4),
     1 N18(2),N17(5),N17(6),N18(3),N17(7),N18(4)
      PRINT                  6020,(N19(J),J=1,19)
      PRINT                  6030,(N20(J),J=1,24)
      PRINT                  6040,N21,(N22(J),J=1,4)
      PRINT                  6050,(N23A(J),J=1,16)
      PRINT                  6060,(N23B(J),J=1,12)
      PRINT                  6070,(N23C(J),J=1,12)
      PRINT                  6080,(N23D(J),J=1,16)
      RETURN
 5000 FORMAT(1H1,109X,5HPAGE I3)
 6000 FORMAT(83X,13H(1) PAGE NO. A2/21X,5H(2) A2,8A6,7X,7H(3)    A4,2A2
     1//21X,77H (4)   (5)   (6)   (7)   (8)   (9)  (10)  (11)  (12)  (1
     23)  (14)  (15)  (16)/24X,A2,4X,A2,1X,A5,4X,2A1,5X,A1,4X,A2,4X,A2,2
     3X,A4,4X,A2,4X,A2,5X,A1,5X,A1,5X,A1)
 6010 FORMAT(1H0,20X,59H(17) AREA DIMENSIONS    SIDE A       SIDE B      (
     118) HEIGHTS/28X,14HEXTERIOR WALLSI8,1I2,13X,8HTOTAL   I9/28X,14HCO
     2RE 1ST STORYI8,1I2,13X,6HBASEMENTI9/28X,16HCORE UPPER STORYI6,1I2,
     313X,9H1ST STORYI8/28X,16HBASEMENT PERCENTI6,9X,3H***,13X,11HUPPER
     4STORYI6)
 6020 FORMAT(1H0,20X,77H(19) ROOF AND SETBACK  HEIGHT         SIDE A      S
     1IDE B       SIDE C        SIDE D/28X,4HROOF,15X,3H***,4I12/28X,13HSET
     2BACK NO. 1I9,4I12/28X,13HSETBACK NO. 2I9,4I12/28X,13HSETBACK NO. 3
     3I9,4I12)
 6030 FORMAT(1H0,20X,77H(20) CONTAMINATED PLANES            SIDE A      S
     1IDE B       SIDE C        SIDE D/28X,27HPLANE 1    EFFECTIVE HEIGHTI7
     2,3I12/39X,14HWIDTH OF PLANEI9,3I12/28X,27HPLANE 2    EFFECTIVE HEI
     3GHTI7,3I12/39X,14HWIDTH OF PLANEI9,3I12/28X,27HPLANE 3    EFFECTIV
     4E HEIGHTI7,3I12/39X,14HWIDTH OF PLANEI9,3I12)
 6040 FORMAT(1H0,20X,23H(21) SURVEY METHOD CODEI6//21X,77H(22) FLOOR AND BSPO
     1 ROOF DESCRIPTION  BASEMENT   1ST FLOOR   UPPER FLOORS     ROOF/50 BSPO
     2X,4I12)                                                           BSPO
 6050 FORMAT(1H0,20X,21H(23) STRUCTURE DETAIL/56X,42HSIDE A       SIDE B  BSPO
     1     SIDE C       SIDE D/28X,24HBASEMENT  EXTERIOR WALLSI10,3I12/38 BSPO
     2X,15HHGT ABOVE GRADEI9,3I12/38X,14HAPERTURES     I10,3I12/38X,14HI BSPO
     3NTERIOR WALLSI10,3I12)                                            BSPO
```

```
6060 FORMAT(1H0,27X,24H1ST STORY EXTERIOR WALLSI10,3I12/38X,14HAPERTURE BSPO
    1S       I10,3I12/38X,14HINTERIOR WALLSI10,3I12)                    BSPO
6070 FORMAT(1H0,27X,24HUPPER       EXTERIOR WALLSI10,3I12/38X,14HAPERTURE BSPO
    1S       I10,3I12/38X,14HINTERIOR WALLSI10,3I12)                    BSPO
6080 FORMAT(1H0,27X,31HUPPER AFTER CONSTRUCTION CHANGE/35X,14HNO CHANGE BSPO
    1        ,9X,1HX,3(11X,1HX)/38X,14HSTORY NUMBER  I10,3I12/38X,14HEXTER BSPO
    2IOR WALLSI10,3I12/38X,14HAPERTURES      I10,3I12/38X,14HINTERIOR WA BSPO
    3LLSI10,3I12)                                                       BSPO
     END
```

```
      SLBROUTINE FOSCAL(WF,TLE,N17,N18,N19,N20,N21,N22,N23A,N23B,
     1 N23C,N23D)
      DIMENSICN WF(45),TLE(27),N17(7), N18(4),N19(19),N20(24),N22(4),
     1 N23A(16),N23B(12),N23C(12),N23D(16)
      CALL F01T16(WF,TLE)
      CALL F017(WF,N17)
      CALL F018(WF,N18)
      CALL F019(WF,N19)
      CALL F020(WF,N2C)
      CALL F021(WF,N21)
      CALL F022(WF,N22)
      CALL F023A(WF,N23A)
      CALL F023B(WF,N23B)
      CALL F023C(WF,N23C)
      CALL F023D(WF,N23D)
      RETURN
      END
```

```
      SUBROUTINE SETUP(I1,M,N,L,A,B)
      DIMENSION N(100),L(800),     A(100),B(100)
      M=0
      DO 100 I=1,I1
      K1=0
      K2=0
      N(I)=0
      DO 50 J=1,8
      K=I1*(J-1)+I
      K1=K1+L(K)*J
      K2=K2+L(K)*J*J
      M=M+L(K)
   50 N(I)=N(I)+L(K)
      IF(N(I))60,60,70
   60 A(I)=0.
      B(I)=0.
      GO TO 100
   70 T1=K1
      T2=K2
      T3=N(I)
      A(I)=T1/T3
      IF(N(I)-1)80,80,90
   80 B(I)=0.
      GO TO 100
   90 C=          (T2-((T1**2)/T3))/(T3-1.0)
      IF(C)80,80,92
   92 B(I)=SQRTF(C)
  100 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE GOOL(I1,I2,K,N,M,A,B)
      DIMENSION N(800),A(9),B(9)
      DO 100 I=1,8
      J=I2*(I-1)+I1
      X1=N(J) *K
      X2=N(J)*K*K
      A(I)=A(I)+X1
  100 B(I)=B(I)+X2
      X1=M *K
      X2=M*K*K
      A(9)=A(9)+X1
      B(9)=B(9)+X2
      RETURN
      END
```

```
      SUBROUTINE COOL(I1,I2,K,N,M,A,B,I3)
C     I1 IS THE LOOP INDEX VALUE AND I2 IS ITS RANGE
      DIMENSION N(800),A(9),B(9)
      Y=I3
      X=K
      X=X+Y/2.0
      DO 100 I=1,8
      J=I2*(I-1)+I1
      X1=N(J)
      X1=X1*X
      X2=X1*X
      A(I)=A(I)+X1
  100 B(I)=B(I)+X2
      X1=M
      X1=X1*X
      X2=X1*X
      A(9)=A(9)+X1
      B(9)=B(9)+X2
      RETURN
      END


      SUBROUTINE TCOL(N,M,A,B)
      DIMENSION N(8),A(9),B(9)
      DO 130 I=1,8
      IF(N(I))130,130,100
  100 X=N(I)
      A(I)=A(I)/X
      IF(N(I)-1)120,120,110
  120 B(I)=0.
      GO TO 130
  110 C=        (B(I)-((A(I)**2)/X))/(X-1.0)
      IF(C)120,120,125
  125 B(I)=SQRTF(C)
  130 CONTINUE
      IF(M)170,170,140
  140 X=M
      A(9)=A(9)/X
      IF(M-1)150,150,160
  150 B(9)=0.
      GO TO 170
  160 C=        (B(9)-((A(9)**2)/X))/(X-1.0)
      IF(C)150,150,165
  165 B(9)=SQRTF(C)
  170 PRINT 4900,(A(I),I=1,9)
      PRINT 4910,(B(I),I=1,9)
      RETURN
 4900 FORMAT(12X,3HAVE,3X,9F7.2)
 4910 FORMAT(12X,3HS D,3X,9F7.2)
      END
```

Appendix D

Source Program Listings for the Subroutines

I. INTRODUCTION

This appendix briefly describes subroutines used by more than one stage of the categorization calculations reported in Appendices A, B, and C (see Chapter 3). Source program listings are included. In planning the study, an attempt was made to sub-program the calculations so that, in proceeding through the various calculational stages, a minimum of repetition of programming would be required. Accordingly, generalized subroutines were written for unpacking the M1 and M2 file data, word masking and shifting, etc.

II. PROGRAM DESCRIPTION

A. SHELT(W,N)

W represents the six word packed M2 file entry (the first two words of the original entry have been deleted) and N represents the thirteen shelter digits expressed as FORTRAN integers, as illustrated in the shelter output, Figure 4 of Chapter 3.

B. F01T16(W,TLE)

W is a 45 word M1 file entry and TLE is the sixteen FOSDIC entries 1-16, subdivided into 27 portions, in BCD form.

C. F017(W,N17), F018(W,N18), F019(W,N19), F020(W,N20), F021(W,N21), F022(W,N22)

Each of these programs unpacks and expresses as FORTRAN integers the entries of the corresponding FOSDIC items. W is a 45 word M1 file entry. For example, N17 is the seven FOSDIC item seventeen entries, in order of presentation on the form from left to right and top to bottom.

D. <u>F023A(W,NA), F023B(W,NB), F023C(W,NC), F023D(W,ND)</u>

FOSDIC item 23 was subdivided into four parts; A, B, C, and D as follows:

Part	Entries
A	23a-23p
B	$23q-23\bar{b}$
C	$23\bar{c}-23\bar{n}$
D	$23\bar{o}-23\bar{d}$

Each entry is expressed as a FORTRAN integer.

E. <u>PFCAT(WN,N)</u>

W is a floating point protection factor and N is the corresponding PF category expressed as a FORTRAN integer.

F. <u>RND(W,N)</u>

W is, in general, a non-integral floating point number and N is the corresponding rounded integer in FORTRAN form.

G. <u>FINCR(W)</u>

The 36 bit integer W is incremented by one.

H. <u>FMASK(W)</u>

The last six bits of word W are set to zero.

I. <u>FCOMP(W1,W2,N)</u>

W1 and W2 are 36 bit integers. N is a FORTRAN integer which has the values zero or one according to whether or not W1 = W2.

J. <u>FSHFT(W1,W2,L,M)</u>

Logical word W1 is shifted left or right M bits according to whether or not L = 0. The result is stored in W2.

K. <u>FTSH(W1,W2,L,M)</u>

Same as FSHFT except that algebraic W1 is used.

L. FMASH(W1,W2,K,L,M,N)

This subroutine selects a word mask by specifying the integer K, shifts it L bits left, masks W1, shifts the result M bits left or right, depending on whether or not N is zero, and stores the results in W2.

Each mask consists of J non-zero consecutive bits completely right justified in the mask word. J and K are related as follows:

K	J
0	36
1	18
2	12
3	9
4	8
5	7
6	6
7	4
8	3

III. SOURCE PROGRAM LISTINGS

```
      SUBROUTINE SHELT(W,N)
      DIMENSION W(6),N(13)
      LL=0
      LR=1
      L3=3
      L10=10
      L15=15
      L18=18
      L21=21
      L28=28
      TOT=0.0
      CALL FSHFT(W(2),N(1),LL,L28)
      CALL FTSH(N(1),N(1),LR,L10)
      CALL FMASH(W(3),W1,LR,L18,LL,LL)
      W1=W1*1000.
      TOT=TOT+W1
      CALL RND(W1,N(2))
      CALL FMASH(W(3),W1,LR,LL,L18,LL)
      W1=W1*1000.
      TOT=TOT+W1
      CALL RND(W1,N(3))
      CALL FMASH(W(4),W1,LR,L18,LL,LL)
      W1=W1*1000.
      TOT=TOT+W1
      CALL RND(W1,N(4))
      CALL FMASH(W(4),W1,LR,LL,L18,LL)
      W1=W1*1000.
      TOT=TOT+W1
      CALL RND(W1,N(5))
      CALL FMASH(W(5),W1,LR,L18,LL,LL)
      W1=W1*1000.
      TOT=TOT+W1
      CALL RND(W1,N(6))
      CALL RND(TOT,N(7))
      CALL FMASH(W(5),W1,LR,LL,L18,LL)
      CALL PFCAT(W1,N(8))
      CALL FSHFT(W(6),N(9),LL,L21)
      CALL FSHFT(N(9),N(9),LR,L3)
      N(9)=N(9)*10
      IF(4-N(8))200,100,400
  100 W1=N(9)
      W1=W1*0.3
      GO TO 500
  200 IF(5-N(8))350,300,300
  300 W1=N(9)
      W1=W1*0.7
      GO TO 500
  350 N(10)=N(9)
      GO TO 600
  400 W1=N(9)
      W1=W1*0.5
  500 CALL RND(W1,N(10))
  600 CALL FMASH(W(6),N(11),LR,L18,LL,LL)
      CALL FMASH(W(2),M,L3,L15,L3,LL)
      IF(N(1)-2)601,602,670
```

```
601 IF(N(1))610,610,602
602 IF(N(11))610,610,603                                              SHELT
603 IF(N(10)-N(11))610,620,620                                        SHELT
610 MNM=N(10)                                                         SHELT
    GO TO 640                                                         SHELT
620 MNM=N(11)
640 N(12)=MNM*M
    IF(N(1))641,641,660                                               SHELT
641 W8=N(12)                                                          SHELT
    W8=W8/500.                                                        SHELT
    CALL RND(W8,N(13))                                                SHELT
    GO TO 680                                                         SHELT
660 W8=MNM                                                            SHELT
    W8=W8/10.                                                         SHELT
    CALL RND(W8,N(13))                                                SHELT
    GO TO 680                                                         SHELT
670 N(12)=0                                                           SHELT
    W8=N(10)                                                          SHELT
    W8=W8/10.                                                         SHELT
    CALL RND(W8,N(13))                                                SHELT
680 RETURN                                                            SHELT
    END
```

```
      SUBROUTINE FO1T16(W,TLE)                                         FO1T16
      DIMENSION W(16),TLE(27)                                          FO1T16
      L6=6                                                             FO1T16
      L12=12                                                           FO1T16
      L24=24                                                           FO1T16
      L30=30                                                           FO1T16
      LL=0                                                             FO1T16
      TLE(1)=W(1)                                                      FO1T16
      CALL FSHFT(W(1),TLE(2),LL,L24)                                   FO1T16
      TLE(3)=W(2)                                                      FO1T16
      CALL FSHFT(W(8),TLE(4),LL,L24)                                   FO1T16
      DO 100 I=1,8                                                     FO1T16
  100 TLE(I+4)=W(I+8)                                                  FO1T16
      CALL FSHFT(W(2),TLE(13),LL,L12)                                  FO1T16
      CALL FSHFT(W(2),TLE(14),LL,L24)                                  FO1T16
      TLE(15)=W(3)                                                     FO1T16
      CALL FSHFT(W(3),TLE(16),LL,L30)                                  FO1T16
      TLE(17)=W(4)                                                     FO1T16
      CALL FSHFT(W(4),TLE(18),LL,L6)                                   FO1T16
      CALL FSHFT(W(4),TLE(19),LL,L24)                                  FO1T16
      TLE(20)=W(5)                                                     FO1T16
      CALL FSHFT(W(5),TLE(21),LL,L12)                                  FO1T16
      TLE(22)=W(6)                                                     FO1T16
      CALL FSHFT(W(6),TLE(23),LL,L12)                                  FO1T16
      CALL FSHFT(W(6),TLE(24),LL,L24)                                  FO1T16
      CALL FSHFT(W(6),TLE(25),LL,L30)                                  FO1T16
      TLE(26)=W(7)                                                     FO1T16
      CALL FSHFT(W(8),TLE(27),LL,L12)                                  FO1T16
      RETURN                                                           FO1T16
      END                                                              FO1T16
```

```
      SUBROUTINE FO17(W,N)                                              FO17
      DIMENSION W(45),N(7)                                              FO17
      LL=0                                                              FO17
      LR=1                                                              FO17
      L2=2                                                              FO17
      L6=6                                                              FO17
      L7=7                                                              FO17
      L12=12                                                            FO17
      L14=14                                                            FO17
      L18=18                                                            FO17
      L24=24                                                            FO17
      L32=32                                                            FO17
      CALL FMASH(W(18),N(1),L2,L24,L6,LR)                               FO17
      CALL FMASH(W(18),N(2),L2,L12,L6,LL)                               FO17
      CALL FMASH(W(18),N(3),L2,LL,L18,LL)                               FO17
      CALL FMASH(W(19),N(4),L2,L24,L6,LR)                               FO17
      CALL FMASH(W(19),N(5),L2,L12,L6,LL)                               FO17
      CALL FMASH(W(19),N(6),L2,LL,L18,LL)                               FO17
      CALL FMASH(W(41),N(7),L7,L32,L14,LR)                              FO17
      RETURN                                                            FO17
      END                                                               FO17
```

```
      SUBROUTINE FO18(W,N)                                              FO18
      DIMENSION W(45),N(4)                                              FO18
      LL=0                                                              FO18
      LP=1                                                              FO18
      L2=2                                                              FO18
      L6=6                                                              FO18
      L12=12                                                            FO18
      L18=18                                                            FO18
      L24=24                                                            FO18
      CALL FMASH(W(20),N(1),L2,L24,L6,LR)                               FO18
      CALL FMASH(W(20),N(2),L2,L12,L6,LL)                               FO18
      CALL FMASH(W(20),N(3),L2,LL,L18,LL)                               FO18
      CALL FMASH(W(21),N(4),L2,L24,L6,LR)                               FO18
      RETURN                                                            FO18
      END                                                               FO18
```

```
      SUBROUTINE FO19(W,N)                                        FO19
      DIMENSION W(45),N(19)                                       FO19
      LL=0                                                        FO19
      LR=1                                                        FO19
      L2=2                                                        FO19
      L3=3                                                        FO19
      L4=4                                                        FO19
      L6=6                                                        FO19
      L7=7                                                        FO19
      L10=10                                                      FO19
      L11=11                                                      FO19
      L12=12                                                      FO19
      L14=14                                                      FO19
      L5=5                                                        FO19
      L18=18                                                      FO19
      L21=21                                                      FO19
      L28=28                                                      FO19
      L24=24                                                      FO19
      CALL FMASH(W(27),N(1),L5,L28,L10,LR)                        FO19
      CALL FMASH(W(27),N(2),L5,L21,L3,LR)                         FO19
      CALL FMASH(W(27),N(3),L5,L14,L4,LL)                         FO19
      CALL FMASH(W(27),N(4),L5,L7,L11,LL)                         FO19
      CALL FMASH(W(21),N(5),L2,L12,L6,LL)                         FO19
      CALL FMASH(W(27),N(6),L5,LL,L18,LL)                         FO19
      CALL FMASH(W(28),N(7),L5,L28,L10,LR)                        FO19
      CALL FMASH(W(28),N(8),L5,L21,L3,LR)                         FO19
      CALL FMASH(W(28),N(9),L5,L14,L4,LL)                         FO19
      CALL FMASH(W(21),N(10),L2,LL,L18,LL)                        FO19
      CALL FMASH(W(26),N(11),L5,L7,L11,LL)                        FO19
      CALL FMASH(W(28),N(12),L5,LL,L18,LL)                        FO19
      CALL FMASH(W(29),N(13),L5,L28,L10,LR)                       FO19
      CALL FMASH(W(29),N(14),L5,L21,L3,LR)                        FO19
      CALL FMASH(W(22),N(15),L2,L24,L6,LR)                        FO19
      CALL FMASH(W(29),N(16),L5,L14,L4,LL)                        FO19
      CALL FMASH(W(29),N(17),L5,L7,L11,LL)                        FO19
      CALL FMASH(W(29),N(18),L5,LL,L18,LL)                        FO19
      CALL FMASH(W(30),N(19),L5,L28,L10,LR)                       FO19
      RETURN                                                      FO19
      END                                                         FO19
```

```
      SUBROUTINE FO20(W,N)                                            FO20
      DIMENSION W(45),N(24)                                           FO20
      LL=0                                                            FO20
      LR=1                                                            FO20
      L2=2                                                            FO20
      L3=3                                                            FO20
      L4=4                                                            FO20
      L5=5                                                            FO20
      L6=6                                                            FO20
      L7=7                                                            FO20
      L10=10                                                          FO20
      L11=11                                                          FO20
      L12=12                                                          FO20
      L14=14                                                          FO20
      L18=18                                                          FO20
      L21=21                                                          FO20
      L24=24                                                          FO20
      L28=28                                                          FO20
      CALL FMASH(W(22),N(1),L2,L12,L12,LL)                            FO20
      CALL FTSH(N(1),N(1),LR,L6)                                      FO20
      CALL FMASH(W(22),N(2),L2,LL,L24,LL)                             FO20
      CALL FTSH(N(2),N(2),LR,L6)                                      FO20
      CALL FMASH(W(23),N(3),L2,L24,LL,LL)                             FO20
      CALL FTSH(N(3),N(3),LR,L6)                                      FO20
      CALL FMASH(W(23),N(4),L2,L12,L12,LL)                            FO20
      CALL FTSH(N(4),N(4),LR,L6)                                      FO20
      CALL FMASH(W(30),N(5),L5,L21,L3,LR)                             FO20
      CALL FMASH(W(30),N(6),L5,L14,L4,LL)                             FO20
      CALL FMASH(W(30),N(7),L5,L7,L11,LL)                             FO20
      CALL FMASH(W(30),N(8),L5,LL,L18,LL)                             FO20
      CALL FMASH(W(23),N(9),L2,LL,L24,LL)                             FO20
      CALL FTSH(N(9),N(9),LR,L6)                                      FO20
      CALL FMASH(W(24),N(10),L2,L24,LL,LL)                            FO20
      CALL FTSH(N(10),N(10),LR,L6)                                    FO20
      CALL FMASH(W(24),N(11),L2,L12,L12,LL)                           FO20
      CALL FTSH(N(11),N(11),LR,L6)                                    FO20
      CALL FMASH(W(24),N(12),L2,LL,L24,LL)                            FO20
      CALL FTSH(N(12),N(12),LR,L6)                                    FO20
      CALL FMASH(W(31),N(13),L5,L28,L10,LR)                           FO20
      CALL FMASH(W(31),N(14),L5,L21,L3,LR)                            FO20
      CALL FMASH(W(31),N(15),L5,L14,L4,LL)                            FO20
      CALL FMASH(W(31),N(16),L5,L7,L11,LL)                            FO20
      CALL FMASH(W(25),N(17),L2,L24,LL,LL)                            FO20
      CALL FTSH(N(17),N(17),LR,L6)                                    FO20
      CALL FMASH(W(25),N(18),L2,L12,L12,LL)                           FO20
      CALL FTSH(N(18),N(18),LR,L6)                                    FO20
      CALL FMASH(W(25),N(19),L2,LL,L24,LL)                            FO20
      CALL FTSH(N(19),N(19),LR,L6)                                    FO20
      CALL FMASH(W(26),N(20),L2,L24,LL,LL)                            FO20
      CALL FTSH(N(20),N(20),LR,L6)                                    FO20
      CALL FMASH(W(31),N(21),L5,LL,L18,LL)                            FO20
      CALL FMASH(W(32),N(22),L5,L28,L10,LR)                           FO20
      CALL FMASH(W(32),N(23),L5,L21,L3,LR)                            FO20
      CALL FMASH(W(32),N(24),L5,L14,L4,LL)                            FO20
      RETURN
      END
```

```
      SUBROUTINE F021(W,N)                                              F021
      DIMENSION W(45)                                                   F021
      LR=1                                                              F021
      L7=7                                                              F021
      L14=14                                                            F021
      L32=32                                                            F021
      CALL FMASH(W(42),N,L7,L32,L14,LR)                                 F021
      RETURN                                                            F021
      END                                                               F021
```

```
      SUBROUTINE F022(W,N)                                              F022
      DIMENSION W(45),N(4)                                              F022
      LL=0                                                              F022
      LR=1                                                              F022
      L3=3                                                              F022
      L5=5                                                              F022
      L7=7                                                              F022
      L10=10                                                            F022
      L11=11                                                            F022
      L18=18                                                            F022
      L21=21                                                            F022
      L28=28                                                            F022
      CALL FMASH(W(32),N(1),L5,L7,L11,LL)                               F022
      CALL FMASH(W(32),N(2),L5,LL,L18,LL)                               F022
      CALL FMASH(W(33),N(3),L5,L28,L10,LR)                              F022
      CALL FMASH(W(33),N(4),L5,L21,L3,LR)                               F022
      RETURN                                                            F022
      END                                                               F022
```

```
      SUBROUTINE FO23A(W,N)                                             FO23A
      DIMENSION W(45),N(16)                                             FO23A
      L28=28                                                            FO23A
      LL=0                                                              FO23A
      LR=1                                                              FO23A
      L2=2                                                              FO23A
      L3=3                                                              FO23A
      L4=4                                                              FO23A
      L5=5                                                              FO23A
      L6=6                                                              FO23A
      L7=7                                                              FO23A
      L8=8                                                              FO23A
      L10=10                                                            FO23A
      L11=11                                                            FO23A
      L12=12                                                            FO23A
      L14=14                                                            FO23A
      L16=16                                                            FO23A
      L18=18                                                            FO23A
      L20=20                                                            FO23A
      L21=21                                                            FO23A
      L24=24                                                            FO23A
      CALL FMASH(W(33),N(1),L5,L14,L4,LL)                               FO23A
      CALL FMASH(W(33),N(2),L5,L7,L11,LL)                               FO23A
      CALL FMASH(W(33),N(3),L5,LL,L18,LL)                               FO23A
      CALL FMASH(W(34),N(4),L5,L28,L10,LR)                              FO23A
      CALL FMASH(W(42),N(5),L7,L28,L10,LR)                              FO23A
      CALL FMASH(W(42),N(6),L7,L24,L6,LR)                               FO23A
      CALL FMASH(W(42),N(7),L7,L20,L2,LR)                               FO23A
      CALL FMASH(W(42),N(8),L7,L16,L2,LL)                               FO23A
      CALL FMASH(W(42),N(9),L7,L12,L6,LL)                               FO23A
      CALL FMASH(W(42),N(10),L7,L8,L10,LL)                              FO23A
      CALL FMASH(W(42),N(11),L7,L4,L14,LL)                              FO23A
      CALL FMASH(W(42),N(12),L7,LL,L18,LL)                              FO23A
      CALL FMASH(W(34),N(13),L5,L21,L3,LR)                              FO23A
      CALL FMASH(W(34),N(14),L5,L14,L4,LL)                              FO23A
      CALL FMASH(W(34),N(15),L5,L7,L11,LL)                              FO23A
      CALL FMASH(W(34),N(16),L5,LL,L18,LL)                              FO23A
      DO 100 I=9,12
  100 W(I)=N(I)*10                                                      FO23A
      RETURN                                                            FO23A
      END
```

```
      SUBROUTINE F023B(W,N)                                             F023B
      DIMENSION W(45),N(12)                                             F023B
      LL=0                                                              F023B
      LR=1                                                              F023B
      L2=2                                                              F023B
      L3=3                                                              F023B
      L4=4                                                              F023B
      L5=5                                                              F023B
      L6=6                                                              F023B
      L7=7                                                              F023B
      L10=10                                                            F023B
      L11=11                                                            F023B
      L14=14                                                            F023B
      L18=18                                                            F023B
      L20=20                                                            F023B
      L21=21                                                            F023B
      L24=24                                                            F023B
      L28=28                                                            F023B
      L32=32                                                            F023B
      CALL FMASH(W(35),N(1),L5,L28,L10,LR)                              F023B
      CALL FMASH(W(35),N(2),L5,L21,L3,LR)                               F023B
      CALL FMASH(W(35),N(3),L5,L14,L4,LL)                               F023B
      CALL FMASH(W(35),N(4),L5,L7,L11,LL)                               F023B
      CALL FMASH(W(43),N(5),L7,L32,L14,LR)                              F023B
      CALL FMASH(W(43),N(6),L7,L28,L10,LR)                              F023B
      CALL FMASH(W(43),N(7),L7,L24,L6,LR)                               F023B
      CALL FMASH(W(43),N(8),L7,L20,L2,LR)                               F023B
      CALL FMASH(W(35),N(9),L5,LL,L18,LL)                               F023B
      CALL FMASH(W(36),N(10),L5,L28,L10,LR)                             F023B
      CALL FMASH(W(36),N(11),L5,L21,L3,LR)                              F023B
      CALL FMASH(W(36),N(12),L5,L14,L4,LL)                              F023B
      DO 100 I=5,8
  100 N(I)=N(I)*10
      RETURN                                                            F023B
      END                                                               F023B
```

```
      SUBROUTINE FO23C(W,N)                                         FO23C
      DIMENSION W(45),N(12)                                         FO23C
      LL=0                                                          FO23C
      LR=1                                                          FO23C
      L2=2                                                          FO23C
      L3=3                                                          FO23C
      L4=4                                                          FO23C
      L5=5                                                          FO23C
      L6=6                                                          FO23C
      L7=7                                                          FO23C
      L8=8                                                          FO23C
      L10=10                                                        FO23C
      L11=11                                                        FO23C
      L12=12                                                        FO23C
      L14=14                                                        FO23C
      L16=16                                                        FO23C
      L18=18                                                        FO23C
      L21=21                                                        FO23C
      L28=28                                                        FO23C
      CALL FMASH(W(36),N(1),L5,L7,L11,LL)                           FO23C
      CALL FMASH(W(36),N(2),L5,LL,L18,LL)                           FO23C
      CALL FMASH(W(37),N(3),L5,L28,L10,LR)                          FO23C
      CALL FMASH(W(37),N(4),L5,L21,L3,LR)                           FO23C
      CALL FMASH(W(43),N(5),L7,L16,L2,LL)                           FO23C
      CALL FMASH(W(43),N(6),L7,L12,L6,LL)                           FO23C
      CALL FMASH(W(43),N(7),L7,L8,L10,LL)                           FO23C
      CALL FMASH(W(43),N(8),L7,L4,L14,LL)                           FO23C
      CALL FMASH(W(37),N(9),L5,L14,L4,LL)                           FO23C
      CALL FMASH(W(37),N(10),L5,L7,L11,LL)                          FO23C
      CALL FMASH(W(37),N(11),L5,LL,L18,LL)                          FO23C
      CALL FMASH(W(38),N(12),L5,L28,L10,LR)                         FO23C
      DO 100 I=5,8
  100 N(I)=N(I)*10
      RETURN                                                        FO23C
      END                                                           FO23C
```

```
      SUBROUTINE FO23D(W,N)                                              FO23D
      DIMENSION W(45),N(16)                                              FO23D
      LL=0                                                               FO23D
      LR=1                                                               FO23D
      L3=3                                                               FO23D
      L4=4                                                               FO23D
      L5=5                                                               FO23D
      L6=6                                                               FO23D
      L7=7                                                               FO23D
      L10=10                                                             FO23D
      L11=11                                                             FO23D
      L14=14                                                             FO23D
      L18=18                                                             FO23D
      L21=21                                                             FO23D
      L24=24                                                             FO23D
      L28=28                                                             FO23D
      L32=32                                                             FO23D
      L127=127
      CALL FMASH(W(38),N(1),L5,L21,L3,LR)                                FO23D
      CALL FMASH(W(38),N(2),L5,L14,L4,LL)                                FO23D
      CALL FMASH(W(38),N(3),L5,L7,L11,LL)                                FO23D
      CALL FMASH(W(39),N(4),L5,LL,L18,LL)                                FO23D
      CALL FMASH(W(39),N(5),L5,L28,L10,LR)                               FO23D
      CALL FMASH(W(39),N(6),L5,L21,L3,LR)                                FO23D
      CALL FMASH(W(39),N(7),L5,L14,L4,LL)                                FO23D
      CALL FMASH(W(39),N(8),L5,L7,L11,LL)                                FO23D
      CALL FMASH(W(43),N(9),L7,LL,L18,LL)                                FO23D
      CALL FMASH(W(44),N(10),L7,L32,L14,LR)                              FO23D
      CALL FMASH(W(44),N(11),L7,L28,L10,LR)                              FO23D
      CALL FMASH(W(44),N(12),L7,L24,L6,LR)                               FO23D
      CALL FMASH(W(39),N(13),L5,LL,L18,LL)                               FO23D
      CALL FMASH(W(40),N(14),L5,L24,L10,LR)                              FO23D
      CALL FMASH(W(40),N(15),L5,L21,L3,LR)                               FO23D
      CALL FMASH(W(40),N(16),L5,L14,L4,LL)                               FO23D
      DO 300 I=1,4
      IF(L127-N(I))200,200,300
  200 N(I)=0
  300 N(I+8)=N(I+8)*10
      RETURN                                                             FO23D
      END                                                                FO23D
```

```
      SUBROUTINE PECAT(W,N)
      IF(100.-W)130,204,100
  100 IF(70.-W)203,203,110
  110 IF(40.-W)202,202,120
  120 IF(20.-W)201,201,200
  130 IF(150.-W)140,205,204
  140 IF(250.-W)150,206,205
  150 IF(500.-W)160,207,206
  160 IF(1000.-W)208,208,207
  200 N=0
      GO TO 300
  201 N=1
      GO TO 300
  202 N=2
      GO TO 300
  203 N=3
      GO TO 300
  204 N=4
      GO TO 300
  205 N=5
      GO TO 300
  206 N=6
      GO TO 300
  207 N=7
      GO TO 300
  208 N=8
  300 RETURN
      END
```

```
      SUBROUTINE RND(W,N)                                    RND
      N1=W                                                   RND
      W1=N1                                                  RND
      W2=W-W1                                                RND
      IF(0.5-W2)200,100,300                                  RND
  100 IF(N1-(N1/2)*2)300,300,200                             RND
  200 N=N1+1                                                 RND
      RETURN                                                 RND
  300 N=N1                                                   RND
      RETURN                                                 RND
      END                                                    RND
```

```
       ENTRY   FINCR
FINCR  CLA*    2,4       INCR. W1 BY THE
       ARS     18        FORTRAN INTG.N1.
       ADD*    1,4          W1,N1
       STO*    1,4
       TRA     3,4
       END


       ENTRY   FMASK
FMASK  CAL*    1,4       SET LAST 6 BITS OF
       ANA     MASK      W TO ZERO
       SLW*    1,4          W
       TRA     2,4
MASK   OCT     777777777700
       END


       ENTRY   FCOMP
FCOMP  CAL*    1,4       COMP. SL..SET INDC.
       ERA*    2,4       W1,W2,NCOMP
       TZE     COMP      NCOMP=0 IF COMPARE
       CLA     ONE       NCOMP=1 OTHERWISE
       STO*    3,4       NCOMP IS FORTRAN INTG.
       TRA     4,4
COMP   SLW*    3,4
       TRA     4,4
ONE    OCT     000001000000
       END
```

```
       ENTRY  FSHFT
       HTR
FSHFT  SXD    *-1,1      W1,W2,LR,NP
       CLA*   4,4        SHIFT LOGICAL
       PDC    0,1        WORD W1 RT OR LFT
       CLA*   3,4        NP BITS ACCORDING
       TZE    *+6        TO WHETHER LR IS
       CAL*   1,4        1 OR 0,RESPECTIVELY.
       ARS    0,1        STORE RESULT IN W2.
       SLW*   2,4
       LXD    FSHFT-1,1
       TRA    5,4
       CAL*   1,4
       ALS    0,1
       SLW*   2,4
       LXD    FSHFT-1,1
       TRA    5,4
       END
```

```
       ENTRY  FTSH
       HTR
FTSH   SXD    *-1,1      W1,W2,LR,NP
       CLA*   4,4
       PDC    0,1        SHIFT W1 RIGHT OR
       CLA*   3,4        LEFT NP BITS
       TZE    *+6        ACCORDING TO WHETHER
       CLA*   1,4        LR IS 1 OR 0,
       ARS    0,1        RESPECTIVELY
       STO*   2,4        STORE RESULT IN W2.
       LXD    FTSH-1,1
       TRA    5,4
       CLA*   1,4
       ALS    0,1
       STO*   2,4
       TRA    *-5
       END
```

```
        ENTRY   FMASH
        HTR
        HTR
FMASH   SXD     *-1,1       W1,W2,MASK,NSF,MSF,LR
        SXD     *-3,2
        CLA*    3,4         SELECT WORD MASK (MASK)
        PDC     0,1         AND SHIFT MASK LEFT NSF
        CLA*    4,4         BITS. MASK WORD
        PDC     0,2         W1. SHIFT MASKED
        CLA*    6,4         WORD MSF BITS EITHER
        TZE     B           LEFT OR RIGHT ACCORDING
        CLA*    5,4         TO WHETHER LR IS 0 OR NOT.
        ARS     18
        STA     *+4         STORE RESULT IN W2.
        CAL     A,1
        ALS     0,2
        ANA*    1,4
        ARS
        SLW*    2,4
        LXD     FMASH-1,1
        LXD     FMASH-2,2
        TRA     7,4
B       CLA*    5,4
        ARS     18
        STA     *+4
        CAL     A,1
        ALS     0,2
        ANA*    1,4
        ALS
        TRA     B-4
A       OCT     777777777777
        OCT     000000777777
        OCT     000000007777
        OCT     000000000777
        OCT     000000000377
        OCT     000000000177
        OCT     000000000077
        OCT     000000000017
        OCT     000000000007
        END
```

Appendix E

Shelter and Building Tabulations by Structural Characteristics

This appendix presents the tabulations made for the 1541 buildings in the statistical sample. Shelters and buildings are categorized by structural characteristics as outlined in Chapter 3 and presented in the following order:

I. SHELTER STATISTICS FOR PF CLASS 1 BUILDINGS

II. SHELTER STATISTICS FOR PF CLASS 2 BUILDINGS

III. SHELTER STATISTICS FOR PF CLASS 3 BUILDINGS

IV. SHELTER STATISTICS FOR PF CLASS 4 BUILDINGS

V. SHELTER STATISTICS FOR PF CLASS 5 BUILDINGS

VI. SHELTER STATISTICS FOR PF CLASS 6 BUILDINGS

VII. SHELTER STATISTICS FOR PF CLASS 7 BUILDINGS

VIII. SHELTER STATISTICS FOR PF CLASS 8 BUILDINGS

IX. TOTAL SHELTER STATISTICS FOR ALL PF CLASSES

X. BUILDING STATISTICS

The column heading numbers in each section refer to the PF class for which that column applies. For example, the section on Shelter Statistics for PF Class 3 has column headings for shelters in PF Classes 1, 2,and 3. This particular section considers only buildings whose highest rated shelter is in PF Category 3.

I. SHELTER STATISTICS FOR PF CLASS 1 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 1 but none higher. There are 483 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B.2. of Chapter 3.

NUMBER OF SHELTERS

STORY NUMBER	1*
0	414
1	109
2	49
3	18
4	8
5	5
6	4
7	2
8	1
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	0
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0
25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	0
34	0
35	0
36	0
37	0
38	0
39	0
40	0
41	0
42	0
43	0
44	0
TOTAL	610
AVE	0.60
S D	1.30

CONTAM. PLANE WIDTH	1
0	59
30	48
60	20
90	13
120	10
150	17
180	3
210	3
240	7
270	4
300	3
330	0
360	0
390	1
420	0
450	0
480	3
510	0
540	0
570	0
600	0
630	0
660	2
690	0
720	0
750	2
780	0
810	0
840	0
870	0
900	0
930	0
960	0
990	1
1020	0
1050	0
1080	0
1110	0
1140	0
1170	0
1200	0
TOTAL	196
AVE	106.99
S D	180.40

PSF	1
0	0
25	0
50	16
75	55
100	165
125	53
150	137
175	49
200	53
225	21
250	17
275	7
300	11
325	7
350	7
375	2
400	2
425	1
450	2
475	5
AVE	163.24
S D	17[illegible].86

FRACTION OF SHELTERS

STORY NUMBER	1
0	0.6787
1	0.1787
2	0.0803
3	0.0295
4	0.0131
5	0.0082
6	0.0066
7	0.0033
8	0.0016
9	0.
10	0.
11	0.
12	0.
13	0.
14	0.
15	0.
16	0.
17	0.
18	0.
19	0.
20	0.
21	0.
22	0.
23	0.
24	0.
25	0.
26	0.
27	0.
28	0.
29	0.
30	0.
31	0.
32	0.
33	0.
34	0.
35	0.
36	0.
37	0.
38	0.
39	0.
40	0.
41	0.
42	0.
43	0.
44	0.
TOTAL	1.0000

CONTAM. PLANE WIDTH	1
0	0.3010
30	0.2449
60	0.1020
90	0.0663
120	0.0510
150	0.0867
180	0.0153
210	0.0153
240	0.0357
270	0.0204
300	0.0153
330	0.
360	0.
390	0.0051
420	0.
450	0.
480	0.0153
510	0.
540	0.
570	0.
600	0.
630	0.
660	0.0102
690	0.
720	0.
750	0.0102
780	0.
810	0.
840	0.
870	0.
900	0.
930	0.
960	0.
990	0.0051
1020	0.
1050	0.
1080	0.
1110	0.
1140	0.
1170	0.
1200	0.

PSF	1
0	0.
25	0.
50	0.0262
75	0.0902
100	0.2705
125	0.0869
150	0.2246
175	0.0803
200	0.0869
225	0.0344
250	0.0279
275	0.0115
300	0.0180
325	0.0115
350	0.0115
375	0.0033
400	0.0033
425	0.0016
450	0.0033
475	0.0082

NUMBER OF SHELTERS

PERCENT APERTURE	1
0	296
10	167
20	82
30	37
40	21
50	5
60	0
70	0
80	2
90	0
AVE	14.30
S D	18.73

LOG FLOOR AREA	1
2	39
3	540
4	29
5	2
6	0
AVE	3.49
S D	3.51

SHELTERS WITH INTERIOR PARTITIONS

1
109

FRACTION OF SHELTERS

PERCENT APERTURE	1
0	0.4852
10	0.2738
20	0.1344
30	0.C6C7
40	0.0344
50	0.0082
60	0.
70	0.
80	0.0C33
90	C.

LOG FLOOR AREA	1
2	C.C639
3	0.8852
4	C.C475
5	0.0033
6	0.

1
0.1787

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

I	1
1	65
2	99
3	7
4	428
5	11
AVE	3.36
S D	3.54

I	1
1	0.1066
2	0.1623
3	0.0115
4	C.7016
5	0.0180

II. SHELTER STATISTICS FOR PF CLASS 2 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 2 but none higher. There are 361 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B.2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	TOTAL	AV PF	S D
0	43	311	354	1.88	0.33
1	78	64	142	1.45	0.50
2	55	21	76	1.28	0.45
3	29	16	45	1.36	0.48
4	18	3	21	1.14	0.36
5	10	1	11	1.09	0.30
6	4	3	7	1.43	0.53
7	3	2	5	1.40	0.55
8	3	1	4	1.25	0.50
9	2	1	3	1.33	0.58
10	3	0	3	1.00	0.
11	3	0	3	1.00	0.
12	3	0	3	1.00	0.
13	2	1	3	1.33	0.58
14	2	1	3	1.33	0.58
15	3	0	3	1.00	0.
16	0	0	0	0.	0.
17	0	0	0	0.	0.
18	0	0	0	0.	0.
19	0	0	0	0.	0.
20	0	0	0	0.	0.
21	0	0	0	0.	0.
22	0	0	0	0.	0.
23	0	0	0	0.	0.
24	0	0	0	0.	0.
25	0	0	0	0.	0.
26	0	0	0	0.	0.
27	0	0	0	0.	0.
28	0	0	0	0.	0.
29	0	0	0	0.	0.
30	0	0	0	0.	0.
31	0	0	0	0.	0.
32	0	0	0	0.	0.
33	0	0	0	0.	0.
34	0	0	0	0.	0.
35	0	0	0	0.	0.
36	0	0	0	0.	0.
37	0	0	0	0.	0.
38	0	0	0	0.	0.
39	0	0	0	0.	0.
40	0	0	0	0.	0.
41	0	0	0	0.	0.
42	0	0	0	0.	0.
43	0	0	0	0.	0.
44	0	0	0	0.	0.
TOTAL	261	425			
AVE	2.61	0.58	1.35		
S D	4.04	1.60	2.79		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	TOTAL
0	0.0627	0.4534	0.5160
1	0.1137	0.0933	0.2070
2	0.0802	0.0306	0.1108
3	0.0423	0.0233	0.0656
4	0.0262	0.0044	0.0306
5	0.0146	0.0015	0.0160
6	0.0058	0.0044	0.0102
7	0.0044	0.0029	0.0073
8	0.0044	0.0015	0.0058
9	0.0029	0.0015	0.0044
10	0.0044	0.	0.0044
11	0.0044	0.	0.0044
12	0.0044	0.	0.0044
13	0.0029	0.0015	0.0044
14	0.0029	0.0015	0.0044
15	0.0044	0.	0.0044
16	0.	0.	0.
17	0.	0.	0.
18	0.	0.	0.
19	0.	0.	0.
20	0.	0.	0.
21	0.	0.	0.
22	0.	0.	0.
23	0.	0.	0.
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	0.	0.	0.
28	0.	0.	0.
29	0.	0.	0.
30	0.	0.	0.
31	0.	0.	0.
32	0.	0.	0.
33	0.	0.	0.
34	0.	0.	0.
35	0.	0.	0.
36	0.	0.	0.
37	0.	0.	0.
38	0.	0.	0.
39	0.	0.	0.
40	0.	0.	0.
41	0.	0.	0.
42	0.	0.	0.
43	0.	0.	0.
44	0.	0.	0.
TOTAL	0.3805	0.6195	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	TOTAL	AV PF	S D
0	33	259	292	1.89	0.32
10	115	90	205	1.44	0.50
20	69	45	114	1.39	0.49
30	31	19	50	1.38	0.49
40	6	3	9	1.33	0.50
50	0	1	1	2.00	0.
60	4	5	9	1.56	0.53
70	3	3	6	1.50	0.55
80	0	0	0	0.	0.
90	0	0	0	0.	0.
AVE	20.90	12.18	15.50		
S D	24.32	17.19	20.18		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	TOTAL
0	0.0481	0.3776	0.4257
10	0.1676	0.1312	0.2988
20	0.1006	0.0656	0.1662
30	0.0452	0.0277	0.0729
40	0.0087	0.0044	0.0131
50	0.	0.0015	0.0015
60	0.0058	0.0073	0.0131
70	0.0044	0.0044	0.0087
80	0.	0.	0.
90	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	TOTAL	AV PF	S D
C	36	39	75	1.52	0.50
30	64	23	87	1.26	0.44
60	25	11	36	1.31	0.47
90	12	4	16	1.25	0.45
120	13	4	17	1.24	0.44
150	3	1	4	1.25	0.5C
180	5	1	6	1.17	0.41
21C	4	2	6	1.33	0.52
240	5	5	10	1.5C	0.53
270	6	2	8	1.25	0.46
300	3	1	4	1.25	0.5C
330	12	4	16	1.25	0.45
360	9	1	10	1.1C	0.32
390	0	2	2	2.00	0.
420	9	2	11	1.18	0.40
450	1	3	4	1.75	0.50
48C	1	2	3	1.67	0.58
510	1	C	1	1.0C	0.
54C	3	1	4	1.25	0.50
570	2	0	2	1.CC	0.
6C0	0	0	0	0.	0.
630	3	3	6	1.50	0.55
660	0	C	C	C.	0.
690	0	0	0	C.	0.
720	1	0	1	1.00	0.
750	0	0	C	0.	0.
780	0	0	C	0.	0.
810	0	0	0	C.	0.
84C	0	0	0	0.	0.
870	0	C	C	C.	0.
900	0	C	C	C.	0.
93C	0	C	C	0.	0.
960	0	0	0	0.	0.
990	0	3	3	2.00	0.
1020	0	0	C	0.	0.
1050	0	C	C	0.	0.
1080	0	0	0	0.	0.
1110	0	C	0	0.	0.
1140	0	C	C	0.	C.
117C	C	C	C	0.	0.
TOTAL	218	114			
AVE	151.51	155.26	152.8C		
S D	222.70	266.66	23?.31		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	TOTAL
0	0.1084	0.1175	0.2259
30	0.1928	0.0693	0.2620
60	C.0753	0.0331	0.1084
90	0.0361	0.0120	0.0482
120	0.0392	0.0120	0.0512
150	0.0090	0.0030	0.0120
180	0.0151	0.0030	0.0181
210	0.0120	0.0060	0.0181
240	0.0151	0.0151	0.0301
27C	0.0181	0.0060	0.0241
300	0.0C90	0.0030	0.0120
330	0.0361	0.0120	0.0482
360	C.C271	0.003C	0.0301
390	0.	0.0060	0.0060
420	0.0271	0.0060	0.0331
450	0.C030	0.0090	0.0120
480	C.0030	0.0C60	0.0090
510	0.CC30	0.	0.0030
540	C.0090	0.0030	0.0120
570	C.0060	0.	0.C060
600	C.	0.	0.
630	0.C090	0.0090	0.0181
660	0.	0.	0.
690	C.	0.	0.
72C	0.0030	0.	0.0030
750	C.	C.	0.
780	0.	C.	0.
810	C.	0.	0.
840	0.	0.	0.
870	0.	0.	0.
900	C.	0.	0.
930	C.	0.	0.
960	0.	0.	0.
990	0.	0.0090	0.0090
1020	0.	0.	0.
1050	0.	0.	0.
1080	0.	0.	0.
111C	0.	0.	0.
114C	0.	0.	0.
1170	0.	0.	0.
TCTAL	0.6566	0.3434	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	TOTAL	AV PF	S D
2	16	50	66	1.76	0.43
3	222	341	563	1.61	0.49
4	23	34	57	1.60	0.49
5	0	0	0	0.	0.
6	0	0	0	0.	0.
AVE	3.53	3.46	3.49		
S D	3.55	3.49	3.52		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	TOTAL
2	0.0233	0.0729	0.0962
3	0.3236	0.4971	0.8207
4	0.0335	0.0496	0.0831
5	0.	0.	0.
6	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	TOTAL	AV PF	S D
29	66	95	1.69	0.46

FRACTION OF SHELTERS PER PF CATEGORY

1	2	TOTAL
C.0423	0.0962	0.1385

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	TOTAL	AV PF	S D
0	0	0	0	0.	0.
25	0	0	C	0.	0.
50	6	10	16	1.62	0.50
75	34	18	52	1.35	0.48
10C	83	83	166	1.5C	0.50
125	46	56	1C2	1.55	0.50
150	50	102	152	1.67	0.47
175	17	29	46	1.63	0.49
20C	12	55	67	1.82	0.39
225	5	26	31	1.84	0.37
250	5	15	20	1.75	0.44
275	1	11	12	1.92	0.29
300	0	9	9	2.C0	0.
325	1	4	5	1.80	0.45
350	1	1	2	1.5C	0.71
375	0	1	1	2.00	0.
400	0	0	C	0.	0.
425	0	C	0	0.	0.
450	0	0	0	0.	0.
475	0	5	5	2.00	0.
AVE	139.32	173.09	160.24		
S D	147.00	186.18	172.21		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	TOTAL
0	0.	0.	0.
25	0.	0.	0.
50	0.0087	0.0146	0.0233
75	0.0496	0.0262	0.0758
100	0.1210	0.1210	0.2420
125	0.0671	0.0816	0.1487
150	0.0729	0.1487	0.2216
175	C.0248	0.0423	0.0671
2C0	0.0175	0.0802	0.0977
225	0.0C73	0.0379	0.0452
250	0.0073	0.0219	0.0292
275	0.0C15	0.0160	0.0175
300	0.	0.0131	0.0131
325	0.0015	0.0058	0.0073
350	C.0C15	0.0015	0.0029
375	0.	0.0015	0.0015
400	0.	0.	0.
425	0.	0.	0.
450	C.	0.	0.
475	0.	0.0073	0.0073

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

I	NUMBER OF SHELTERS PER PF CATEGORY 1	2	TOTAL	AV PF	S D
1	52	39	91	1.43	0.50
2	84	82	166	1.49	0.50
3	7	4	11	1.36	0.50
4	113	289	402	1.72	0.45
5	5	11	16	1.69	0.48
AVE	2.75	3.36	3.13		
S D	3.03	3.54	3.35		

I	FRACTION OF SHELTERS PER PF CATEGORY 1	2	TOTAL
1	0.0758	0.0569	0.1327
2	0.1224	0.1195	0.2420
3	0.0102	0.0058	0.0160
4	0.1647	0.4213	0.5860
5	0.0073	0.0160	0.0233

III. SHELTER STATISTICS FOR PF CLASS 3 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 3 but none higher. There are 150 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	TOTAL	AV PF	S D
0	8	17	135	160	2.79	0.52
1	50	10	15	75	1.53	0.81
2	36	9	6	51	1.41	0.70
3	16	7	1	24	1.37	0.58
4	10	2	0	12	1.17	0.39
5	0	2	1	3	2.33	0.58
6	2	0	0	2	1.00	0.
7	0	0	0	0	0.	0.
8	0	0	0	0	0.	0.
9	0	0	0	0	0.	0.
10	0	0	0	0	0.	0.
11	0	0	0	0	0.	0.
12	0	0	0	0	0.	0.
13	0	0	0	0	0.	0.
14	0	0	0	0	0.	0.
15	0	0	0	0	0.	0.
16	0	0	0	0	0.	0.
17	0	0	0	0	0.	0.
18	0	0	0	0	0.	0.
19	0	0	0	0	0.	0.
20	0	0	0	0	0.	0.
21	0	0	0	0	0.	0.
22	0	0	0	0	0.	0.
23	0	0	0	0	0.	0.
24	0	0	0	0	0.	0.
25	0	0	0	0	0.	0.
26	0	0	0	0	0.	0.
27	0	0	0	0	0.	0.
28	0	0	0	0	0.	0.
29	0	0	0	0	0.	0.
30	0	0	0	0	0.	0.
31	0	0	0	0	0.	0.
32	0	0	0	0	0.	0.
33	0	0	0	0	0.	0.
34	0	0	0	0	0.	0.
35	0	0	0	0	0.	0.
36	0	0	0	0	0.	0.
37	0	0	0	0	0.	0.
38	0	0	0	0	0.	0.
39	0	0	0	0	0.	0.
40	0	0	0	0	0.	0.
41	0	0	0	0	0.	0.
42	0	0	0	0	0.	0.
43	0	0	0	0	0.	0.
44	0	0	0	0	0.	0.
TOTAL	122	47	158			
AVE	1.82	1.43	0.22	0.99		
S D	2.17	2.04	0.68	1.60		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	TOTAL
0	0.0245	0.0520	0.4128	0.4893
1	0.1529	0.0306	0.0459	0.2294
2	0.1101	0.0275	0.0183	0.1560
3	0.0489	0.0214	0.0031	0.0734
4	0.0306	0.0061	0.	0.0367
5	0.	0.0061	0.0031	0.0092
6	0.0061	0.	0.	0.0061
7	0.	0.	0.	0.
8	0.	0.	0.	0.
9	0.	0.	0.	0.
10	0.	0.	0.	0.
11	0.	0.	0.	0.
12	0.	0.	0.	0.
13	0.	0.	0.	0.
14	0.	0.	0.	0.
15	0.	0.	0.	0.
16	0.	0.	0.	0.
17	0.	0.	0.	0.
18	0.	0.	0.	0.
19	0.	0.	0.	0.
20	0.	0.	0.	0.
21	0.	0.	0.	0.
22	0.	0.	0.	0.
23	0.	0.	0.	0.
24	0.	0.	0.	0.
25	0.	0.	0.	0.
26	0.	0.	0.	0.
27	0.	0.	0.	0.
28	0.	0.	0.	0.
29	0.	0.	0.	0.
30	0.	0.	0.	0.
31	0.	0.	0.	0.
32	0.	0.	0.	0.
33	0.	0.	0.	0.
34	0.	0.	0.	0.
35	0.	0.	0.	0.
36	0.	0.	0.	0.
37	0.	0.	0.	0.
38	0.	0.	0.	0.
39	0.	0.	0.	0.
40	0.	0.	0.	0.
41	0.	0.	0.	0.
42	0.	0.	0.	0.
43	0.	0.	0.	0.
44	0.	0.	0.	0.
TOTAL	0.3731	0.1437	0.4832	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	TOTAL	AV PF	S D
0	12	9	104	125	2.74	0.62
10	41	20	44	105	2.03	0.90
20	40	8	8	56	1.43	0.74
30	20	7	1	28	1.32	0.55
40	9	3	1	13	1.38	0.65
50	C	0	0	0	0.	0.
60	0	0	0	0	0.	0.
70	0	0	0	C	0.	0.
80	0	0	0	0	0.	0.
90	0	0	0	0	0.	0.
AVE	22.79	19.68	9.24	15.80		
S D	25.27	23.02	11.50	19.37		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	TOTAL
0	0.0367	0.0275	0.3180	0.3823
10	0.1254	0.0612	0.1346	0.3211
20	0.1223	0.0245	0.0245	0.1713
30	0.0612	0.0214	0.0031	0.0856
40	0.C275	0.0092	0.0031	0.0398
50	0.	0.	0.	0.
60	0.	0.	0.	0.
70	0.	0.	0.	0.
80	0.	0.	0.	0.
90	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	TOTAL	AV PF	S D
0	33	11	13	57	1.65	0.83
30	39	6	3	48	1.25	0.56
60	12	3	1	16	1.31	0.60
90	8	1	0	9	1.11	0.33
120	7	1	1	9	1.33	0.71
150	4	2	0	6	1.33	0.52
180	1	2	1	4	2.00	0.82
210	1	0	0	1	1.00	0.
240	5	0	1	6	1.33	0.82
270	2	4	1	7	1.86	0.69
300	0	0	0	0	0.	0.
330	1	0	1	2	2.00	1.41
360	0	0	0	0	0.	0.
390	0	0	0	0	0.	0.
420	0	0	0	0	0.	0.
450	0	0	0	0	0.	0.
480	0	0	0	0	0.	0.
510	0	0	1	1	3.00	0.
540	1	0	0	1	1.00	0.
570	0	0	0	0	0.	0.
600	0	0	0	0	0.	0.
630	0	0	0	0	0.	0.
660	0	0	0	0	0.	0.
690	0	0	0	0	0.	0.
720	0	0	0	0	0.	0.
750	0	0	0	0	0.	0.
780	0	0	0	0	0.	0.
810	0	0	0	0	0.	0.
840	0	0	0	0	0.	0.
870	0	0	0	0	0.	0.
900	0	0	0	0	0.	0.
930	0	0	0	0	0.	0.
960	0	0	0	0	0.	0.
990	0	0	0	0	0.	0.
1020	0	0	0	0	0.	0.
1050	0	0	0	0	0.	0.
1080	0	0	0	0	0.	0.
1110	0	0	0	0	0.	0.
1140	0	0	0	0	0.	0.
1170	0	0	0	0	0.	0.
TOTAL	114	30	23			
AVE	76.84	92.00	93.26	81.83		
S D	114.51	133.37	166.71	125.38		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	TOTAL
0	0.1976	0.0659	0.0778	0.3413
30	0.2335	0.0359	0.0180	0.2874
60	0.0719	0.0180	0.0060	0.0958
90	0.0479	0.0060	0.	0.0539
120	0.0419	0.0060	0.0060	0.0539
150	0.0240	0.0120	0.	0.0359
180	0.0060	0.0120	0.0060	0.0240
210	0.0060	0.	0.	0.0060
240	0.0299	0.	0.0060	0.0359
270	0.0120	0.0240	0.0060	0.0419
300	0.	0.	0.	0.
330	0.0060	0.	0.0060	0.0120
360	0.	0.	0.	0.
390	0.	0.	0.	0.
420	0.	0.	0.	0.
450	0.	0.	0.	0.
480	0.	0.	0.	0.
510	0.	0.	0.0060	0.0060
540	0.0060	0.	0.	0.0060
570	0.	0.	0.	0.
600	0.	0.	0.	0.
630	0.	0.	0.	0.
660	0.	0.	0.	0.
690	0.	0.	0.	0.
720	0.	0.	0.	0.
750	0.	0.	0.	0.
780	0.	0.	0.	0.
810	0.	0.	0.	0.
840	0.	0.	0.	0.
870	0.	0.	0.	0.
900	0.	0.	0.	0.
930	0.	0.	0.	0.
960	0.	0.	0.	0.
990	0.	0.	0.	0.
1020	0.	0.	0.	0.
1050	0.	0.	0.	0.
1080	0.	0.	0.	0.
1110	0.	0.	0.	0.
1140	0.	0.	0.	0.
1170	0.	0.	0.	0.
TOTAL	0.6826	0.1796	0.1377	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	TOTAL	AV PF	S D
2	5	0	11	16	2.37	0.96
3	104	40	129	273	2.09	0.92
4	13	7	18	38	2.13	0.91
5	0	0	0	0	0.	0.
6	0	0	0	0	0.	0.
AVE	3.57	3.65	3.54	3.57		
S D	3.60	3.71	3.58	3.60		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	TOTAL
2	0.0153	0.	0.0336	0.0489
3	0.3180	0.1223	0.3945	0.8349
4	0.0398	0.0214	0.0550	0.1162
5	0.	0.	0.	0.
6	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	TOTAL	AV PF	S D
19	13	23	55	2.07	0.88

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	TOTAL
0.0581	0.0398	0.0703	0.1682

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	TOTAL	AV PF	S D
0	0	0	0	0	0.	0.
25	0	0	0	0	0.	0.
50	3	C	0	3	1.C0	0.
75	7	5	3	15	1.73	0.8C
1C0	55	13	27	95	1.71	0.89
125	9	6	18	33	2.27	0.88
150	19	7	44	70	2.36	0.89
175	11	4	15	3C	2.13	0.94
200	10	7	23	4C	2.32	0.86
225	2	1	5	8	2.37	0.92
25C	3	1	6	1C	2.30	0.95
275	1	0	7	8	2.75	0.71
3C0	0	0	4	4	3.00	0.
325	1	2	2	5	2.20	0.84
350	1	1	3	5	2.40	0.89
375	0	0	0	0	C.	0.
400	0	0	0	C	C.	0.
425	0	0	0	0	0.	0.
450	0	C	1	1	3.00	0.
475	0	0	0	0	0.	0.
AVE	145.49	162.5C	182.75	165.94		
S D	155.32	177.04	194.40	177.70		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	TOTAL
0	0.	0.	0.	0.
25	0.	0.	0.	0.
50	C.0092	0.	0.	0.0092
75	C.0214	0.0153	0.0092	0.0459
100	0.1682	0.0398	0.0826	0.2905
125	0.0275	0.0183	0.0550	0.1009
150	C.0581	0.0214	0.1346	0.2141
175	0.0336	0.0122	0.0459	0.0917
2C0	0.C306	0.0214	0.07C3	0.1223
225	0.0061	0.0031	0.0153	0.0245
250	0.0C92	0.0031	0.0183	0.0306
275	C.CC31	0.	0.0214	0.0245
300	0.	C.	0.0122	C.0122
325	C.0C31	0.CC61	0.0061	0.C153
350	C.0C31	0.0031	0.0092	0.0153
375	0.	0.	0.	0.
400	0.	0.	0.	0.
425	0.	0.	0.	0.
450	C.	0.	0.0031	0.0C31
475	0.	0.	0.	0.

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

I	NUMBER OF SHELTERS PER PF CATEGORY						I	FRACTION OF SHELTERS PER PF CATEGORY			
	1	2	3	TOTAL	AV PF	S D		1	2	3	TOTAL
1	20	7	13	40	1.82	0.90	1	0.0612	0.0214	0.0398	0.1223
2	28	17	22	67	1.91	0.87	2	0.0856	0.0520	0.0673	0.2049
3	1	3	6	10	2.50	0.71	3	0.0031	0.0092	0.0183	0.0306
4	64	19	108	191	2.23	0.92	4	0.1957	0.0581	0.3303	0.5841
5	9	1	9	19	2.00	1.00	5	0.0275	0.0031	0.0275	0.0581
AVE	3.11	2.79	3.49	3.25							
S D	3.39	3.06	3.66	3.47							

IV. SHELTER STATISTICS FOR PF CLASS 4 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 4 but none higher. There are 142 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	TOTAL	AV PF	S D
0	6	9	10	131	156	3.71	0.75
1	46	19	2	13	80	1.77	1.10
2	44	16	5	3	68	1.51	0.82
3	18	6	1	2	27	1.52	0.89
4	10	1	0	0	11	1.09	0.30
5	2	1	0	0	3	1.33	0.58
6	1	1	0	0	2	1.50	0.71
7	1	1	0	0	2	1.50	0.71
8	1	0	1	0	2	2.00	1.41
9	1	1	0	0	2	1.50	0.71
10	1	0	1	0	2	2.00	1.41
11	0	0	1	0	1	3.00	0.
12	1	0	0	0	1	1.00	0.
13	0	0	0	0	0	0.	0.
14	0	0	0	0	0	0.	0.
15	0	0	0	0	0	0.	0.
16	0	0	0	0	0	0.	0.
17	0	0	0	0	0	0.	0.
18	0	0	0	0	0	0.	0.
19	0	0	0	0	0	0.	0.
20	0	0	0	0	0	0.	0.
21	0	0	0	0	0	0.	0.
22	0	0	0	0	0	0.	0.
23	0	0	0	0	0	0.	0.
24	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0.	0.
26	0	0	0	0	0	0.	0.
27	0	0	0	0	0	0.	0.
28	0	0	0	0	0	0.	0.
29	0	0	0	0	0	0.	0.
30	0	0	0	0	0	0.	0.
31	0	0	0	0	0	0.	0.
32	0	0	0	0	0	0.	0.
33	0	0	0	0	0	0.	0.
34	0	0	0	0	0	0.	0.
35	0	0	0	0	0	0.	0.
36	0	0	0	0	0	0.	0.
37	0	0	0	0	0	0.	0.
38	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0.	0.
TOTAL	132	55	21	149			
AVE	2.20	1.82	2.10	0.17	1.29		
S D	2.86	2.52	3.97	0.54	2.23		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	TOTAL
0	0.0168	0.0252	0.0280	0.3669	0.4370
1	0.1289	0.0532	0.0056	0.0364	0.2241
2	0.1232	0.0448	0.0140	0.0084	0.1905
3	0.0504	0.0168	0.0028	0.0056	0.0756
4	0.0280	0.0028	0.	0.	0.0308
5	0.0056	0.0028	0.	0.	0.0084
6	0.0028	0.0028	0.	0.	0.0056
7	0.0028	0.0028	0.	0.	0.0056
8	0.0028	0.	0.0028	0.	0.0056
9	0.0028	0.0028	0.	0.	0.0056
10	0.0028	0.	0.0028	0.	0.0056
11	0.	0.	0.0028	0.	0.0028
12	0.0028	0.	0.	0.	0.0028
13	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.
TOTAL	0.3697	0.1541	0.0588	0.4174	

PERCENT APERTURE	NUMBER OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL	AV PF	S D
0	22	17	6	98	143	3.26	1.17
10	47	17	10	34	108	2.29	1.31
20	40	16	0	13	69	1.80	1.15
30	17	5	5	1	28	1.64	0.91
40	1	0	0	0	1	1.00	0.
50	4	0	0	2	6	2.00	1.55
60	1	0	0	1	2	2.50	2.12
70	0	0	0	0	0	0.	0.
80	0	0	0	0	0	0.	0.
90	0	0	0	0	0	0.	0.
AVE	20.76	16.64	16.90	10.30	15.53		
S D	23.97	19.42	20.63	14.17	19.40		

PERCENT APERTURE	FRACTION OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL
0	0.0616	0.0476	0.0168	0.2745	0.4006
10	0.1317	0.0476	0.0280	0.0952	0.3025
20	0.1120	0.0448	0.	0.0364	0.1933
30	0.0476	0.0140	0.0140	0.0028	0.0784
40	0.0028	0.	0.	0.	0.0028
50	0.0112	0.	0.	0.0056	0.0168
60	0.0028	0.	0.	0.0028	0.0056
70	0.	0.	0.	0.	0.
80	0.	0.	0.	0.	0.
90	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	TOTAL	AV PF	S D
0	36	11	2	8	57	1.68	1.07
30	36	9	3	3	51	1.47	0.86
60	12	1	1	1	15	1.40	0.91
90	16	9	1	2	28	1.61	0.88
120	5	5	2	3	15	2.20	1.15
150	3	5	2	0	10	1.90	0.74
180	0	0	0	0	0	0.	0.
210	3	0	0	1	4	1.75	1.50
240	1	1	0	0	2	1.50	0.71
270	0	0	0	0	0	0.	0.
300	0	1	0	0	1	2.00	0.
330	3	0	0	0	3	1.00	0.
360	5	1	0	0	6	1.17	0.41
390	1	1	0	0	2	1.50	0.71
420	1	1	0	0	2	1.50	0.71
450	2	1	0	0	3	1.33	0.58
480	0	0	0	0	0	0.	0.
510	0	0	0	0	0	0.	0.
540	0	0	0	0	0	0.	0.
570	0	0	0	0	0	0.	0.
600	0	0	0	0	0	0.	0.
630	0	0	0	0	0	0.	0.
660	1	0	0	0	1	1.00	0.
690	0	0	0	0	0	0.	0.
720	0	0	0	0	0	0.	0.
750	0	0	0	0	0	0.	0.
780	0	0	0	0	0	0.	0.
810	1	0	0	0	1	1.00	0.
840	0	0	0	0	0	0.	0.
870	0	0	0	0	0	0.	0.
900	0	0	0	0	0	0.	0.
930	0	0	0	0	0	0.	0.
960	0	0	0	0	0	0.	0.
990	0	0	0	0	0	0.	0.
1020	0	0	0	0	0	0.	0.
1050	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0.	0.
1140	0	0	0	0	0	0.	0.
1170	0	0	0	0	0	0.	0.
TOTAL	126	46	11	18			
AVE	103.33	116.09	85.91	65.00	101.87		
S D	171.97	165.12	106.49	90.95	160.92		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	TOTAL
0	0.1791	0.0547	0.0100	0.0398	0.2836
30	0.1791	0.0448	0.0149	0.0149	0.2537
60	0.0597	0.0050	0.0050	0.0050	0.0746
90	0.0796	0.0448	0.0050	0.0100	0.1393
120	0.0249	0.0249	0.0100	0.0149	0.0746
150	0.0149	0.0249	0.0100	0.	0.0498
180	0.	0.	0.	0.	0.
210	0.0149	0.	0.	0.0050	0.0199
240	0.0050	0.0050	0.	0.	0.0100
270	0.	0.	0.	0.	0.
300	0.	0.0050	0.	0.	0.0050
330	0.0149	0.	0.	0.	0.0149
360	0.0249	0.0050	0.	0.	0.0299
390	0.0050	0.0050	0.	0.	0.0100
420	0.0050	0.0050	0.	0.	0.0100
450	0.0100	0.0050	0.	0.	0.0149
480	0.	0.	0.	0.	0.
510	0.	0.	0.	0.	0.
540	0.	0.	0.	0.	0.
570	0.	0.	0.	0.	0.
600	0.	0.	0.	0.	0.
630	0.	0.	0.	0.	0.
660	0.0050	0.	0.	0.	0.0050
690	0.	0.	0.	0.	0.
720	0.	0.	0.	0.	0.
750	0.	0.	0.	0.	0.
780	0.	0.	0.	0.	0.
810	0.0050	0.	0.	0.	0.0050
840	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.
960	0.	0.	0.	0.	0.
990	0.	0.	0.	0.	0.
1020	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.
1140	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.	0.
TOTAL	0.6269	0.2289	0.0547	0.0896	

LOG FLOOR AREA	NUMBER OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL	AV PF	S D
2	13	C	1	17	31	2.71	1.49
3	111	53	18	116	298	2.47	1.33
4	8	2	2	16	28	2.93	1.36
5	0	C	0	C	0	C.	0.
6	0	C	0	C	0	0.	0.
AVE	3.46	3.54	3.55	3.49	3.49		
S D	3.50	3.57	3.65	3.54	3.52		

LOG FLOCR AREA	FRACTION OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL
2	C.0364	0.	0.0028	0.0476	0.0868
3	0.3109	0.1485	0.0504	0.3249	0.8347
4	C.0224	0.0056	0.0056	0.C448	0.0784
5	C.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	TOTAL	AV PF	S D
15	7	1	29	52	2.85	1.36

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	TOTAL
C.0420	0.C196	0.0028	0.C812	0.1457

PSF	NUMBER OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL	AV PF	S D
0	0	0	0	0	0	0.	0.
25	4	0	0	0	4	1.00	0.
50	2	0	0	2	4	2.50	1.73
75	5	2	0	0	7	1.29	0.49
100	63	23	8	24	118	1.94	1.19
125	20	9	3	15	47	2.28	1.31
150	23	7	4	36	70	2.76	1.38
175	6	7	0	17	30	2.93	1.28
200	6	4	2	20	32	3.12	1.24
225	1	1	3	13	18	3.56	0.86
250	1	0	1	2	4	3.00	1.41
275	0	1	0	9	10	3.80	0.63
300	1	0	0	4	5	3.40	1.34
325	0	0	0	2	2	4.00	0.
350	0	0	0	0	0	0.	0.
375	0	0	0	0	0	0.	0.
400	0	0	0	0	0	0.	0.
425	0	0	0	0	0	0.	0.
450	0	0	0	2	2	4.00	0.
475	0	1	0	3	4	3.50	1.00
AVE	132.58	151.14	160.12	192.53	162.08		
S D	139.22	164.68	171.87	200.28	175.92		

PSF	FRACTION OF SHELTERS PER PF CATEGORY 1	2	3	4	TOTAL
0	0.	0.	0.	0.	0.
25	0.0112	0.	0.	0.	0.0112
50	0.0056	0.	0.	0.0056	0.0112
75	0.0140	0.0056	0.	0.	0.0196
100	0.1765	0.0644	0.0224	0.0672	0.3305
125	0.0560	0.0252	0.0084	0.0420	0.1317
150	0.0644	0.0196	0.0112	0.1008	0.1961
175	0.0168	0.0196	0.	0.0476	0.0840
200	0.0168	0.0112	0.0056	0.0560	0.0896
225	0.0028	0.0028	0.0084	0.0364	0.0504
250	0.0028	0.	0.0028	0.0056	0.0112
275	0.	0.0028	0.	0.0252	0.0280
300	0.0028	0.	0.	0.0112	0.0140
325	0.	0.	0.	0.0056	0.0056
350	0.	0.	0.	0.	0.
375	0.	0.	0.	0.	0.
400	0.	0.	0.	0.	0.
425	0.	0.	0.	0.	0.
450	0.	0.	0.	0.0056	0.0056
475	0.	0.0028	0.	0.0084	0.0112

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	TOTAL	AV PF	S D
1	13	11	3	9	36	2.22	1.20
2	47	19	12	35	113	2.31	1.30
3	0	1	0	C	1	2.00	3.
4	68	22	4	99	193	2.69	1.40
5	4	2	2	6	14	2.71	1.33
AVE	3.C2	2.73	2.52	3.39	3.1C		
S D	3.26	3.C4	2.87	3.57	3.32		

FRACTION OF SHELTERS PER PF CATEGORY

I	1	2	3	4	TOTAL
1	C.0364	0.0308	0.0084	0.0252	0.1008
2	C.1317	0.0532	0.0336	0.098C	0.3165
3	C.	0.0028	3.	0.	0.0028
4	C.19C5	0.0616	C.C112	0.2773	0.5406
5	C.C112	0.0056	0.C056	0.C168	0.C392

V. SHELTER STATISTICS FOR PF CLASS 5 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 5 but none higher. There are 110 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	6	7	10	13	116	0	0	0	152	4.49	1.07
1	40	14	3	4	6	0	0	0	67	1.84	1.30
2	39	18	3	3	4	0	0	0	67	1.73	1.14
3	25	8	4	2	1	0	0	0	40	1.65	1.03
4	12	2	0	2	0	0	0	0	16	1.50	1.03
5	2	2	2	0	1	0	0	0	7	2.43	1.40
6	3	2	0	0	1	0	0	0	6	2.00	1.55
7	3	1	0	0	0	0	0	0	4	1.25	0.50
8	2	1	0	0	0	0	0	0	3	1.33	0.58
9	3	0	0	0	0	0	0	0	3	1.00	0.
10	0	1	0	0	0	0	0	0	1	2.00	0.
11	0	1	0	0	0	0	0	0	1	2.00	0.
12	0	1	0	0	0	0	0	0	1	2.00	0.
13	0	1	0	0	0	0	0	0	1	2.00	0.
14	0	0	0	0	0	0	0	0	0	0.	0.
15	0	0	0	0	0	0	0	0	0	0.	0.
16	0	0	0	0	0	0	0	0	0	0.	0.
17	0	0	0	0	0	0	0	0	0	0.	0.
18	0	0	0	0	0	0	0	0	0	0.	0.
19	0	0	0	0	0	0	0	0	0	0.	0.
20	0	0	0	0	0	0	0	0	0	0.	0.
21	0	0	0	0	0	0	0	0	0	0.	0.
22	0	0	0	0	0	0	0	0	0	0.	0.
23	0	0	0	0	0	0	0	0	0	0.	0.
24	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
26	0	0	0	0	0	0	0	0	0	0.	0.
27	0	0	0	0	0	0	0	0	0	0.	0.
28	0	0	0	0	0	0	0	0	0	0.	0.
29	0	0	0	0	0	0	0	0	0	0.	0.
30	0	0	0	0	0	0	0	0	0	0.	0.
31	0	0	0	0	0	0	0	0	0	0.	0.
32	0	0	0	0	0	0	0	0	0	0.	0.
33	0	0	0	0	0	0	0	0	0	0.	0.
34	0	0	0	0	0	0	0	0	0	0.	0.
35	0	0	0	0	0	0	0	0	0	0.	0.
36	0	0	0	0	0	0	0	0	0	0.	0.
37	0	0	0	0	0	0	0	0	0	0.	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	135	59	22	24	129	0	0	0			
AVE	2.47	2.80	1.41	1.00	0.22	0.	0.	0.	1.57		
S D	3.10	4.07	2.19	1.69	0.85	0.	0.	0.	2.61		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0163	0.0190	0.0271	0.0352	0.3144	0.	0.	0.	0.4119
1	0.1084	0.0379	0.0081	0.0108	0.0163	0.	0.	0.	0.1816
2	0.1057	0.0488	0.0081	0.0081	0.0108	0.	0.	0.	0.1816
3	0.0678	0.0217	0.0108	0.0054	0.0027	0.	0.	0.	0.1084
4	0.0325	0.0054	0.	0.0054	0.	0.	0.	0.	0.0434
5	0.0054	0.0054	0.0054	0.	0.0027	0.	0.	0.	0.0190
6	0.0081	0.0054	0.	0.	0.0027	0.	0.	0.	0.0163
7	0.0081	0.0027	0.	0.	0.	0.	0.	0.	0.0108
8	0.0054	0.0027	0.	0.	0.	0.	0.	0.	0.0081
9	0.0081	0.	0.	0.	0.	0.	0.	0.	0.0081
10	0.	0.0027	0.	0.	0.	0.	0.	0.	0.0027
11	0.	0.0027	0.	0.	0.	0.	0.	0.	0.0027
12	0.	0.0027	0.	0.	0.	0.	0.	0.	0.0027
13	0.	0.0027	0.	0.	0.	0.	0.	0.	0.0027
14	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.3659	0.1599	0.0596	0.0650	0.3496	0.	0.	0.	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	12	7	12	8	96	0	0	0	135	4.25	1.33
10	39	16	2	10	21	0	0	0	88	2.52	1.68
20	59	27	5	4	10	0	0	0	105	1.85	1.27
30	15	9	3	1	2	0	0	0	30	1.87	1.17
40	6	0	0	1	0	0	0	0	7	1.43	1.13
50	4	0	0	0	0	0	0	0	4	1.00	0.
60	0	0	0	0	0	0	0	0	0	0.	0.
70	0	0	0	0	0	0	0	0	0	0.	0.
80	0	0	0	0	0	0	0	0	0	0.	0.
90	0	0	0	0	0	0	0	0	0	0.	0.
AVE	23.22	21.44	14.55	15.42	3.64	0.	0.	0.	16.82		
S D	25.71	23.37	18.95	18.87	11.12	0.	0.	0.	20.31		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0325	0.0190	0.0325	0.C217	0.2602	0.	C.	0.	0.3659
10	C.1057	0.0434	0,0054	0.C271	0.C569	0.	0.	0.	0.2385
20	0.1599	0.0732	0.0136	0.0108	0.0271	0.	0.	0.	0.2846
30	0.0407	0.0244	0.0081	0.0C27	0.0054	0.	0.	0.	0.0813
40	0.0163	0.	C.	0.0C27	C.	0.	0.	0.	0.0190
50	0.0108	0.	0.	0.	0.	0.	C.	0.	0.0108
60	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	0.	0.	C.	0.	0.	0.	0.	0.	0.
80	0.	0.	0.	0.	0.	0.	0.	0.	0.
90	C.	0.	C.	0.	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	29	12	2	4	5	0	0	0	52	1.92	1.34
30	29	19	5	2	1	0	0	0	56	1.70	0.91
60	16	2	1	0	1	0	0	0	20	1.40	0.99
90	10	6	1	0	2	0	0	0	19	1.84	1.26
120	9	1	0	1	1	0	0	0	12	1.67	1.37
150	7	3	0	1	2	0	0	0	13	2.08	1.55
180	6	7	1	3	0	0	0	0	17	2.06	1.09
210	0	1	1	0	0	0	0	0	2	2.50	0.71
240	4	0	0	0	0	0	0	0	4	1.00	0.
270	3	0	0	0	0	0	0	0	3	1.00	0.
300	3	0	0	0	0	0	0	0	3	1.00	0.
330	5	1	0	0	1	0	0	0	7	1.71	1.50
360	0	0	0	0	0	0	0	0	0	0.	0.
390	2	0	1	0	0	0	0	0	3	1.67	1.15
420	1	0	0	0	0	0	0	0	1	1.00	0
450	0	0	0	0	0	0	0	0	0	0.	0.
480	1	0	0	0	0	0	0	0	1	1.00	0.
510	0	0	0	0	0	0	0	0	0	0.	0.
540	1	0	0	0	0	0	0	0	1	1.00	0.
570	0	0	0	0	0	0	0	0	0	0.	0.
600	0	0	0	0	0	0	0	0	0	0.	0.
630	0	0	0	0	0	0	0	0	0	0.	0.
660	1	0	0	0	0	0	0	0	1	1.00	0.
690	0	0	0	0	0	0	0	0	0	0.	0.
720	0	0	0	0	0	0	0	0	0	0.	0.
750	0	0	0	0	0	0	0	0	0	0.	0.
780	0	0	0	0	0	0	0	0	0	0.	0.
810	1	0	0	0	0	0	0	0	1	1.00	0.
840	0	0	0	0	0	0	0	0	0	0.	0.
870	0	0	0	0	0	0	0	0	0	0.	0.
900	0	0	0	0	0	0	0	0	0	0.	0.
930	0	0	0	0	0	0	0	0	0	0.	0.
960	0	0	0	0	0	0	0	0	0	0.	0.
990	1	0	0	0	0	0	0	0	1	1.00	0.
1020	0	0	0	0	0	0	0	0	0	0.	0.
1050	0	0	0	0	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0	0	0	0	0.	0.
1140	0	0	0	0	0	0	0	0	0	0.	0.
1170	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	129	52	12	11	13	0	0	0			
AVE	130.81	84.23	105.00	94.09	93.46	0.	0.	0.	114.12		
S D	206.56	113.26	159.25	127.93	135.97	0.	0.	0.	177.20		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL
0	0.1336	0.0553	0.0092	0.0184	0.0230	0.	0.	0.	0.2396
30	0.1336	0.0876	0.0230	0.0092	0.0046	0.	0.	0.	0.2581
60	0.0737	0.0092	0.0046	0.	0.0046	0.	0.	0.	0.0922
90	0.0461	0.0276	0.0046	0.	0.0092	0.	0.	0.	0.0876
120	0.0415	0.0046	0.	0.0046	0.0046	0.	0.	0.	0.0553
150	0.0323	0.0138	0.	0.0046	0.0092	0.	0.	0.	0.0599
180	0.0276	0.0323	0.0046	0.0138	0.	0.	0.	0.	0.0783
210	0.	0.0046	0.0046	0.	0.	0.	0.	0.	0.0092
240	0.0184	0.	0.	0.	0.	0.	0.	0.	0.0184
270	0.0138	0.	0.	0.	0.	0.	0.	0.	0.0138
300	0.0138	0.	0.	0.	0.	0.	0.	0.	0.0138
330	0.0230	0.0046	0.	0.	0.0046	0.	0.	0.	0.0323
360	0.	0.	0.	0.	0.	0.	0.	0.	0.
390	0.0092	0.	0.0046	0.	0.	0.	0.	0.	0.0138
420	0.0046	0.	0.	0.	0.	0.	0.	0.	0.0046
450	0.	0.	0.	0.	0.	0.	0.	0.	0.
480	0.0046	0.	0.	0.	0.	0.	0.	0.	0.0046
510	0.	0.	0.	0.	0.	0.	0.	0.	0.
540	0.0046	0.	0.	0.	0.	0.	0.	0.	0.0046
570	0.	0.	0.	0.	0.	0.	0.	0.	0.
600	0.	0.	0.	0.	0.	0.	0.	0.	0.
630	0.	0.	0.	0.	0.	0.	0.	0.	0.
660	0.0046	0.	0.	0.	0.	0.	0.	0.	0.0046
690	0.	0.	0.	0.	0.	0.	0.	0.	0.
720	0.	0.	0.	0.	0.	0.	0.	0.	0.
750	0.	0.	0.	0.	0.	0.	0.	0.	0.
780	0.	0.	0.	0.	0.	0.	0.	0.	0.0046
810	0.0046	0.	0.	0.	0.	0.	0.	0.	0.
840	0.	0.	0.	0.	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.	0.	0.	0.	0.
960	0.	0.	0.	0.	0.	0.	0.	0.	0.
990	0.0046	0.	0.	0.	0.	0.	0.	0.	0.0046
1020	0.	0.	0.	0.	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.	0.	0.	0.	0.
1140	0.	0.	0.	0.	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.5945	0.2396	0.0553	0.0507	0.0599	0.	0.	0.	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	15	1	3	2	21	0	0	0	42	3.31	1.87
3	109	54	16	16	92	0	0	0	287	2.75	1.73
4	11	4	3	6	16	0	0	0	40	3.30	1.71
5	0	0	0	0	0	0	0	0	0	0.	0.
6	0	0	0	0	0	0	0	0	0	0.	0.
AVE	3.47	3.55	3.50	3.67	3.46	0.	0.	0.	3.49		
S D	3.51	3.59	3.62	3.78	3.52	0.	0.	0.	3.53		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL
2	0.0407	0.0027	0.0081	0.0054	0.0569	0.	0.	0.	0.1138
3	0.2954	0.1463	0.0434	0.0434	0.2493	0.	0.	0.	0.7778
4	0.0298	0.0103	0.0081	0.0163	0.0434	0.	0.	0.	0.1084
5	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
12	11	4	7	26	C	0	0	60	3.40	1.65

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL
C.0325	0.0298	0.C108	0.C19[illegible]	0.0705	0.	C.	0.	0.1626

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
50	2	C	0	C	1	C	0	0	3	2.33	2.31
75	5	C	0	0	3	0	0	0	8	2.50	2.07
100	63	29	8	3	14	0	0	0	117	1.94	1.34
125	21	8	4	4	2C	C	0	0	57	2.89	1.77
150	30	11	5	7	34	0	0	0	87	3.05	1.78
175	7	3	0	0	8	0	0	0	18	2.94	1.92
200	3	4	2	6	16	0	0	0	31	3.90	1.42
225	3	3	1	2	15	0	0	0	24	3.96	1.55
250	0	0	0	C	2	0	0	0	2	5.00	0.
275	1	C	1	0	5	0	0	0	7	4.14	1.57
300	0	1	0	1	6	C	0	0	8	4.50	1.07
325	0	0	0	1	3	0	0	0	4	4.75	0.50
350	0	0	0	C	0	0	0	0	0	C.	0.
375	0	0	0	0	0	0	0	0	0	0.	0.
400	0	0	0	0	C	0	0	0	0	0.	0.
425	0	C	0	C	C	0	0	C	0	0.	0.
45C	C	0	C	0	0	C	0	0	C	0.	0.
475	0	C	1	C	2	0	0	0	3	4.33	1.15
AVE	136.02	145.55	168.18	184.37	189.63	0.	C.	0.	161.35		
S D	141.05	153.20	192.06	196.97	203.17	C.	C.	C.	172.74		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	C.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	C.	0.	0.	0.
50	0.0054	0.	0.	0.	0.C027	0.	C.	0.	0.0081
75	C.0136	0.	0.	0.	0.0C81	0.	C.	0.	0.0217
100	C.1707	0.0786	0.0217	0.C081	C.0379	C.	C.	0.	0.3171
125	0.0569	0.0217	0.0108	0.C108	0.C542	0.	0.	0.	0.1545
150	0.0813	C.0298	0.C136	0.0190	0.C921	C.	0.	0.	0.2358
175	C.0190	0.0C81	0.	0.	0.C217	C.	C.	0.	0.0488
200	0.0081	0.0108	0.0054	0.C163	0.0434	0.	C.	0.	0.0840
225	0.0081	0.0081	C.0027	0.0054	0.C4C7	C.	C.	0.	0.0650
250	C.	0.	0.	0.	0.C054	C.	0.	0.	0.0054
275	0.C027	0.	0.0027	0.	G.C136	C.	G.	0.	0.0190
300	C.	0.0C27	C.	0.CC27	0.C163	0.	C.	0.	0.0217
325	0.	0.	0.	0.CC27	0.C081	C.	C.	0.	0.0108
350	0.	0.	0.	0.	0.	0.	0.	0.	0.
375	0.	0.	0.	0.	0.	C.	G.	0.	0.
400	0.	0.	0.	0.	0.	0.	C.	0.	0.
425	0.	0.	0.	0.	0.	0.	0.	0.	0.
450	0.	0.	0.	0.	0.	0.	0.	0.	0.
475	0.	0.	0.0027	0.	0.0054	0.	0.	0.	0.0081

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	24	10	1	6	4	0	0	0	45	2.02	1.39
2	48	22	9	12	31	0	0	0	122	2.64	1.66
3	6	1	1	2	7	0	0	0	17	3.18	1.85
4	53	26	11	3	81	0	0	0	174	3.19	1.80
5	4	0	0	1	6	0	0	0	11	3.45	1.97
AVE	2.74	2.73	3.00	2.21	3.42	0.	0.	0.	2.96		
S D	3.01	3.00	3.25	2.51	3.58	0.	0.	0.	3.19		

FRACTION OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL
1	0.0650	0.0271	0.0027	0.0163	0.0108	0.	0.	0.	0.1220
2	0.1301	0.0596	0.0244	0.0325	0.0840	0.	0.	0.	0.3306
3	0.0163	0.0027	0.0027	0.0054	0.0190	0.	0.	0.	0.0461
4	0.1436	0.0705	0.0298	0.0081	0.2195	0.	0.	0.	0.4715
5	0.0108	0.	0.	0.0027	0.0163	0.	0.	0.	0.0298

VI. SHELTER STATISTICS FOR PF CLASS 6 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 6 but none higher. There are 104 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0028	0.0277	0.0111	0.0083	0.0277	0.2798	0.	0.	0.3573
1	0.0970	0.0748	0.0249	0.0083	0.0194	0.0332	0.	0.	0.2576
2	0.1247	0.0388	0.0194	0.0055	0.0055	0.0028	0.	0.	0.1967
3	0.0720	0.0194	0.0055	0.	0.0055	0.0028	0.	0.	0.1053
4	0.0360	0.0028	0.0028	0.	0.0028	0.0055	0.	0.	0.0499
5	0.0083	0.0028	0.0055	0.0028	0.	0.	0.	0.	0.0194
6	0.0028	0.0055	0.	0.	0.	0.	0.	0.	0.0083
7	0.0028	0.	0.	0.	0.	0.	0.	0.	0.0028
8	0.0028	0.	0.	0.	0.	0.	0.	0.	0.0028
9	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	
TOTAL	0.2490	0.1717	0.0693	0.024[illegible]	0.0609	0.3241	0.	0.	

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	1	10	4	3	10	101	0	0	129	5.43	1.26
1	35	27	9	3	7	12	0	0	93	2.53	1.76
2	45	14	7	2	2	1	0	0	71	1.66	1.11
3	26	7	2	0	2	1	0	0	38	1.63	1.24
4	13	1	1	0	1	2	0	0	18	1.94	1.80
5	3	1	2	1	0	0	0	0	7	2.14	1.21
6	1	2	0	0	0	0	0	0	3	1.67	0.58
7	1	0	0	0	0	0	0	0	1	1.00	0.
8	1	0	0	0	0	0	0	0	1	1.00	0.
9	0	0	0	0	0	0	0	0	0	0.	0.
10	0	0	0	0	0	0	0	0	0	0.	0.
11	0	0	0	0	0	0	0	0	0	0.	0.
12	0	0	0	0	0	0	0	0	0	0.	0.
13	0	0	0	0	0	0	0	0	0	0.	0.
14	0	0	0	0	0	0	0	0	0	0.	0.
15	0	0	0	0	0	0	0	0	0	0.	0.
16	0	0	0	0	0	0	0	0	0	0.	0.
17	0	0	0	0	0	0	0	0	0	0.	0.
18	0	0	0	0	0	0	0	0	0	0.	0.
19	0	0	0	0	0	0	0	0	0	0.	0.
20	0	0	0	0	0	0	0	0	0	0.	0.
21	0	0	0	0	0	0	0	0	0	0.	0.
22	0	0	0	0	0	0	0	0	0	0.	0.
23	0	0	0	0	0	0	0	0	0	0.	0.
24	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
26	0	0	0	0	0	0	0	0	0	0.	0.
27	0	0	0	0	0	0	0	0	0	0.	0.
28	0	0	0	0	0	0	0	0	0	0.	0.
29	0	0	0	0	0	0	0	0	0	0.	0.
30	0	0	0	0	0	0	0	0	0	0.	0.
31	0	0	0	0	0	0	0	0	0	0.	0.
32	0	0	0	0	0	0	0	0	0	0.	0.
33	0	0	0	0	0	0	0	0	0	0.	0.
34	0	0	0	0	0	0	0	0	0	0.	0.
35	0	0	0	0	0	0	0	0	0	0.	0.
36	0	0	0	0	0	0	0	0	0	0.	0.
37	0	0	0	0	0	0	0	0	0	0.	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	126	62	25	9	22	117	0	0			
AVE	2.31	1.56	1.72	1.33	C.95	0.21	0.	0.	1.35		
S D	2.65	2.06	2.24	2.12	1.53	0.70	0.	0.	1.97		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0028	0.0277	0.0111	0.0083	0.0277	0.2798	0.	0.	0.3573
1	0.0970	0.0748	0.0249	0.0083	0.0194	0.0332	0.	0.	0.2576
2	0.1247	0.0388	0.0194	0.0055	0.0055	0.0028	0.	0.	0.1967
3	0.0720	0.0194	0.0055	0.	0.0055	0.0028	0.	0.	0.1053
4	0.0360	0.0028	0.0028	0.	0.0028	0.0055	0.	0.	0.0499
5	0.0083	0.0028	0.0055	0.0028	0.	0.	0.	0.	0.0194
6	0.0028	0.0055	0.	0.	0.	0.	0.	0.	0.0083
7	0.0028	0.	0.	0.	0.	0.	0.	0.	0.0028
8	0.0028	0.	0.	0.	0.	0.	0.	0.	0.0028
9	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.3490	0.1717	0.0693	0.[illegible]24[illegible]	0.0609	0.3241	0.	0.	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	21	18	9	4	12	33	0	0	157	4.57	1.97
10	57	21	2	2	2	12	0	0	96	2.03	1.71
20	32	16	11	1	1	12	0	0	73	2.44	1.80
30	14	4	2	1	2	0	0	0	23	1.83	1.30
40	2	3	1	1	1	0	0	0	8	2.50	1.41
50	0	0	0	0	4	0	0	0	4	5.00	0.
60	0	0	0	0	0	0	0	0	0	0.	0.
70	0	0	0	0	0	0	0	0	0	0.	0.
80	0	0	0	0	0	0	0	0	0	0.	0.
90	0	0	0	0	0	0	0	0	0	0.	0.
AVE	18.57	17.42	18.60	17.22	20.45	8.08	0.	0.	15.06		
S D	20.89	20.70	22.37	23.43	29.22	10.39	0.	0.	18.83		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0582	0.0499	0.0249	0.0111	0.0332	0.2576	0.	0.	0.4349
10	0.1579	0.0582	0.0055	0.0055	0.0055	0.0332	0.	0.	0.2659
20	0.0886	0.0443	0.0305	0.0028	0.0028	0.0332	0.	0.	0.2022
30	0.0388	0.0111	0.0055	0.0028	0.0055	0.	0.	0.	0.0637
40	0.0055	0.0083	0.0028	0.0028	0.0028	0.	0.	0.	0.0222
50	0.	0.	0.	0.	0.0111	0.	0.	0.	0.0111
60	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	0.	0.	0.	0.	0.	0.	0.	0.	0.
80	0.	0.	0.	0.	0.	0.	0.	0.	0.
90	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	24	22	2	2	4	2	0	0	56	2.04	1.36
30	27	7	4	C	2	3	0	0	43	1.88	1.52
60	16	5	1	0	0	2	0	0	24	1.71	1.43
90	15	2	0	1	0	1	0	0	19	1.53	1.31
12C	5	2	5	1	C	C	0	0	13	2.15	1.07
150	1C	7	3	0	3	1	0	0	24	2.25	1.54
180	1C	1	1	1	C	1	0	0	14	1.79	1.53
210	2	0	1	0	1	C	0	C	4	2.50	1.91
240	2	3	0	0	0	C	0	0	5	1.60	0.55
270	3	C	1	0	0	0	0	0	4	1.50	1.00
300	1	2	1	1	1	C	0	0	6	2.83	1.47
330	1	0	0	0	0	C	0	C	1	1.00	0.
360	5	0	1	0	1	0	0	C	7	1.86	1.57
390	0	1	0	C	0	C	0	C	1	2.00	0.
420	1	0	0	C	0	0	0	0	1	1.00	0.
450	0	0	0	C	C	0	0	0	0	0.	0.
480	2	0	1	0	0	0	0	0	3	1.67	1.15
510	0	0	0	C	0	0	0	0	0	0.	0.
54C	1	0	0	0	0	0	0	0	1	1.00	0.
570	0	0	0	0	C	0	0	C	0	0.	0.
600	0	0	0	0	C	0	0	0	0	0.	0.
630	0	0	0	0	C	0	0	C	0	C.	0.
660	0	0	0	0	C	1	0	0	1	6.C0	0.
690	0	0	0	0	0	3	0	C	3	6.00	0.
720	0	C	0	0	0	C	0	0	C	0.	0.
750	0	C	0	0	0	1	0	0	1	6.00	0.
780	0	0	0	0	C	0	0	0	0	0.	0.
810	0	0	0	0	0	0	0	0	0	0.	0.
840	0	C	0	C	0	0	0	0	0	0.	0.
870	0	0	0	0	0	C	0	0	C	0.	0.
900	C	C	0	0	G	0	0	0	0	0.	0.
930	0	0	0	0	0	0	0	0	0	0.	0.
960	0	C	0	0	0	1	0	0	1	6.00	0.
990	0	0	0	0	C	0	0	C	0	0.	0.
1020	0	0	0	0	0	0	0	C	0	0.	0.
1050	0	0	0	0	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0	0	C	0	0.	0.
1140	0	0	0	0	0	0	0	C	0	0.	0.
1170	0	0	0	0	0	0	0	C			
TCTAL	125	52	21	6	12	16					
AVE	119.64	89.42	159.29	130.00	13C.C0	343.12	0.	C.	132.67		
S D	166.62	132.23	205.00	181.18	184.81	506.39	0.	0.	203.58		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL
0	0.1034	0.0948	0.0086	0.0086	0.0172	0.0086	0.	0.	0.2414
30	0.1164	0.0302	0.0172	0.	0.0086	0.0129	0.	0.	0.1853
60	0.0690	0.0216	0.0043	0.	0.	0.0086	0.	0.	0.1034
90	0.0647	0.0086	0.	0.0043	0.	0.0043	0.	0.	0.0819
120	0.0216	0.0086	0.0216	0.0043	0.	0.	0.	0.	0.0560
150	0.0431	0.0302	0.0129	0.	0.0129	0.0043	0.	0.	0.1034
180	0.0431	0.0043	0.0043	0.0043	0.	0.0043	0.	0.	0.0603
210	0.0086	0.	0.0043	0.	0.0043	0.	0.	0.	0.0172
240	0.0086	0.0129	0.	0.	0.	0.	0.	0.	0.0216
270	0.0129	0.	0.0043	0.	0.	0.	0.	0.	0.0172
300	0.0043	0.0086	0.0043	0.0043	0.0043	0.	0.	0.	0.0259
330	0.0043	0.	0.	0.	0.	0.	0.	0.	0.0043
360	0.0216	0.	0.0043	0.	0.0043	0.	0.	0.	0.0302
390	0.	0.0043	0.	0.	0.	0.	0.	0.	0.0043
420	0.0043	0.	0.	0.	0.	0.	0.	0.	0.0043
450	0.	0.	0.	0.	0.	0.	0.	0.	0.
480	0.0086	0.	0.0043	0.	0.	0.	0.	0.	0.0129
510	0.	0.	0.	0.	0.	0.	0.	0.	0.
540	0.0043	0.	0.	0.	0.	0.	0.	0.	0.0043
570	0.	0.	0.	0.	0.	0.	0.	0.	0.
600	0.	0.	0.	0.	0.	0.	0.	0.	0.
630	0.	0.	0.	0.	0.	0.	0.	0.	0.
660	0.	0.	0.	0.	0.	0.	0.	0.	0.
690	0.	0.	0.	0.	0.	0.0043	0.	0.	0.0043
720	0.	0.	0.	0.	0.	0.0129	0.	0.	0.0129
750	0.	0.	0.	0.	0.	0.	0.	0.	0.
780	0.	0.	0.	0.	0.	0.0043	0.	0.	0.0043
810	0.	0.	0.	0.	0.	0.	0.	0.	0.
840	0.	0.	0.	0.	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.	0.	0.	0.	0.
960	0.	0.	0.	0.	0.	0.0043	0.	0.	0.0043
990	0.	0.	0.	0.	0.	0.	0.	0.	0.
1020	0.	0.	0.	0.	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.	0.	0.	0.	0.
1140	0.	0.	0.	0.	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.5388	0.2241	0.0905	0.0259	0.0517	0.0690	0.	0.	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	10	1	1	0	0	10	0	0	22	3.41	2.46
3	98	52	13	6	19	86	0	0	274	3.20	2.17
4	18	9	11	3	3	21	0	0	65	3.42	2.07
5	0	0	0	0	0	0	0	0	0	0.	0.
6	0	0	0	0	0	0	0	0	0	0.	0.
AVE	3.56	3.63	3.90	3.83	3.64	3.59	0.	0.	3.62		
S D	3.61	3.68	4.02	4.07	3.73	3.64	0.	0.	3.66		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL
2	0.0277	0.0028	0.0028	0.	0.	0.0277	0.	0.	0.0609
3	0.2715	0.1440	0.0360	0.0166	0.0526	0.2382	0.	0.	0.7590
4	0.0499	0.0249	0.0305	0.0083	0.0083	0.0582	0.	0.	0.1801
5	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
27	15	13	5	12	31	0	C	103	3.51	2.05

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TCTAL
C.C748	C.C416	C.C360	0.C139	0.C332	0.0859	G.	0.	C.2853

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
50	5	3	2	2	2	1	0	0	15	2.73	1.71
75	8	3	1	0	1	0	0	0	13	1.69	1.18
100	55	12	4	0	2	9	0	0	82	1.89	1.65
125	23	13	6	0	2	12	0	0	56	2.66	1.98
150	16	18	2	1	2	29	0	0	68	3.62	2.21
175	8	4	2	1	3	14	0	0	32	3.91	2.19
200	4	3	3	1	1	14	0	0	26	4.31	2.05
225	2	2	0	0	0	8	0	0	12	4.50	2.24
250	3	3	4	2	2	8	0	0	22	3.95	1.91
275	0	1	1	0	6	3	0	0	11	4.82	1.25
300	0	0	0	C	0	5	0	0	5	6.00	0.
325	2	0	0	2	0	1	0	0	5	3.20	2.17
350	0	0	0	0	0	2	0	0	2	6.00	0.
375	0	0	0	C	0	1	0	0	1	6.00	0.
400	0	0	0	0	1	1	0	0	2	5.50	0.71
425	0	0	0	0	0	3	0	0	3	6.00	0.
450	0	0	0	0	0	2	0	0	2	6.00	0.
475	0	0	0	0	0	4	0	0	4	6.00	0.
AVE	136.90	152.42	166.50	209.72	203.41	218.06	0.	0.	173.79		
S D	145.42	161.22	182.04	243.74	227.20	238.94	0.	0.	191.59		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.0139	0.0083	0.0055	0.0055	0.0055	0.0028	0.	0.	0.0416
75	0.0222	0.0083	0.0028	0.	0.0028	0.	0.	0.	0.0360
100	0.1524	0.0332	0.0111	0.	0.0055	0.0249	0.	0.	0.2271
125	0.0637	0.0360	0.0166	0.	0.0055	0.0332	0.	0.	0.1551
150	0.0443	0.0499	0.0055	0.0028	0.0055	0.0803	0.	0.	0.1884
175	0.0222	0.0111	0.0055	0.0028	0.0083	0.0388	0.	0.	0.0886
200	0.0111	0.0083	0.0083	0.0028	0.0028	0.0388	0.	0.	0.0720
225	0.0055	0.0055	0.	0.	0.	0.0222	0.	0.	0.0332
250	0.0083	0.0083	0.0111	0.0055	0.0055	0.0222	0.	0.	0.0609
275	0.	0.0028	0.0028	0.	0.0166	0.0083	0.	0.	0.0305
300	0.	0.	0.	0.	0.	0.0139	0.	0.	0.0139
325	0.0055	0.	0.	0.0055	0.	0.0028	0.	0.	0.0139
350	0.	0.	0.	0.	0.	0.0055	0.	0.	0.0055
375	0.	0.	0.	0.	0.	0.0028	0.	0.	0.0028
400	0.	0.	0.	0.	0.0028	0.0028	0.	0.	0.0055
425	0.	0.	0.	0.	0.	0.0083	0.	0.	0.0083
450	0.	0.	0.	0.	0.	0.0055	0.	0.	0.0055
475	0.	0.	0.	0.	0.	0.0111	0.	0.	0.0111

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 4C PERCENT OR GREATER
I=5 CEILING AND CNE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	17	11	3	C	2	7	0	0	40	2.50	1.89
2	50	25	10	4	7	29	0	0	125	2.84	2.04
3	4	2	0	C	5	7	0	0	18	4.17	2.12
4	50	2C	11	5	7	7C	0	0	163	3.67	2.24
5	5	4	1	0	1	4	0	0	15	3.00	2.14
AVE	2.81	2.69	2.88	3.11	2.91	3.30	0.	C.	2.97		
S D	3.07	3.00	3.19	3.44	3.17	3.48	0.	C.	3.20		

FRACTION OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL
1	0.0471	0.0305	0.0083	0.	0.0C55	0.0194	0.	0.	0.1108
2	C.1385	0.0693	0.0277	0.C111	0.C194	0.C803	C.	0.	C.3463
3	C.C111	0.0C55	0.	0.	0.C139	C.0194	C.	0.	0.0499
4	C.1385	0.0554	C.C305	0.C139	C.C194	C.1939	C.	0.	0.4515
5	C.0139	0.C111	C.C028	0.	C.C028	C.0111	C.	0.	C.0416

VII. SHELTER STATISTICS FOR PF CLASS 7 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 7 but none higher. There are 57 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	2	8	5	6	4	10	57	0	92	5.83	1.83
1	24	10	8	2	2	1	4	0	51	2.35	1.83
2	40	15	2	5	0	2	1	0	65	1.77	1.34
3	16	11	3	2	1	1	0	0	34	1.94	1.25
4	15	2	2	1	1	0	0	0	21	1.62	1.16
5	10	1	1	1	0	0	0	0	13	1.46	0.97
6	3	1	0	1	0	0	0	0	5	1.80	1.30
7	2	2	0	1	0	0	0	0	5	2.00	1.22
8	2	2	1	0	0	0	0	0	5	1.80	0.84
9	1	1	2	0	0	0	0	0	4	2.25	0.96
10	1	0	2	1	0	0	0	0	4	2.75	1.26
11	0	1	2	1	0	0	0	0	4	3.00	0.82
12	0	1	2	1	0	0	0	0	4	3.00	0.82
13	0	2	1	1	0	0	0	0	4	2.75	0.96
14	1	2	1	0	0	0	0	0	4	2.00	0.82
15	3	1	0	0	0	0	0	0	4	1.25	0.50
16	0	1	0	0	0	0	0	0	1	2.00	0.
17	0	1	0	0	0	0	0	0	1	2.00	0.
18	0	1	0	0	0	0	0	0	1	2.00	0.
19	0	1	0	0	0	0	0	0	1	2.00	0.
20	1	0	0	0	0	0	0	0	1	1.00	0.
21	0	0	0	0	0	0	0	0	0	0.	0.
22	0	0	0	0	0	0	0	0	0	0.	0.
23	0	0	0	0	0	0	0	0	0	0.	0.
24	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
26	0	0	0	0	0	0	0	0	0	0.	0.
27	0	0	0	0	0	0	0	0	0	0.	0.
28	0	0	0	0	0	0	0	0	0	0.	0.
29	0	0	0	0	0	0	0	0	0	0.	0.
30	0	0	0	0	0	0	0	0	0	0.	0.
31	0	0	0	0	0	0	0	0	0	0.	0.
32	0	0	0	0	0	0	0	0	0	0.	0.
33	0	0	0	0	0	0	0	0	0	0.	0.
34	0	0	0	0	0	0	0	0	0	0.	0.
35	0	0	0	0	0	0	0	0	0	0.	0.
36	0	0	0	0	0	0	0	0	0	0.	0.
37	0	0	0	0	0	0	0	0	0	0.	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	121	64	32	23	8	14	62	0			
AVE	3.37	4.58	4.78	3.76	1.12	0.57	0.10	0.	2.97		
S D	4.66	6.32	6.77	5.64	1.96	1.13	0.36	0.	4.91		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0062	0.0247	0.0154	0.0185	0.0123	0.0309	0.1759	0.	0.2840
1	0.0741	0.0309	0.0247	0.0062	0.0062	0.0031	0.0123	0.	0.1574
2	0.1235	0.0463	0.0062	0.0154	0.	0.0062	0.0031	0.	0.2006
3	0.0494	0.0340	0.0093	0.0062	0.0031	0.0031	0.	0.	0.1049
4	0.0463	0.0062	0.0062	0.0031	0.0031	0.	0.	0.	0.0648
5	0.0309	0.0031	0.0031	0.0031	0.	0.	0.	0.	0.0401
6	0.0093	0.0031	0.	0.0031	0.	0.	0.	0.	0.0154
7	0.0062	0.0062	0.	0.0031	0.	0.	0.	0.	0.0154
8	0.0062	0.0062	0.0031	0.	0.	0.	0.	0.	0.0154
9	0.0031	0.0031	0.0062	0.	0.	0.	0.	0.	0.0123
10	0.0031	0.	0.0062	0.0031	0.	0.	0.	0.	0.0123
11	0.	0.0031	0.0062	0.0031	0.	0.	0.	0.	0.0123
12	0.	0.0031	0.0062	0.0031	0.	0.	0.	0.	0.0123
13	0.	0.0062	0.0031	0.0031	0.	0.	0.	0.	0.0123
14	0.0031	0.0062	0.0031	0.	0.	0.	0.	0.	0.0123
15	0.0093	0.0031	0.	0.	0.	0.	0.	0.	0.0031
16	0.	0.0031	0.	0.	0.	0.	0.	0.	0.0031
17	0.	0.0031	0.	0.	0.	0.	0.	0.	0.0031
18	0.	0.0031	0.	0.	0.	0.	0.	0.	0.0031
19	0.	0.0031	0.	0.	0.	0.	0.	0.	0.0031
20	0.0031	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	
TOTAL	0.3735	0.1975	0.0988	0.0710	0.0247	0.0432	0.1914	0.	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	12	5	6	6	1	11	55	0	96	5.42	2.25
10	31	19	8	7	6	3	4	0	78	2.53	1.79
20	37	21	5	4	0	0	1	0	68	1.72	1.08
30	36	18	13	5	0	0	2	0	74	1.96	1.28
40	4	1	0	1	1	0	0	0	7	2.14	1.68
50	0	0	0	0	0	0	0	0	0	0.	0.
60	0	0	0	0	0	0	0	0	0	0.	0.
70	1	0	0	0	0	0	0	0	1	1.00	0.
80	0	0	0	0	0	0	0	0	0	0.	0.
90	0	0	0	0	0	0	0	0	0	0.	0.
AVE	24.50	23.59	22.81	19.78	17.50	7.14	6.94	0.	19.54		
S D	27.11	25.69	26.02	23.70	21.91	8.53	9.36	0.	23.14		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0370	0.0154	0.0185	0.0185	0.0031	0.0340	C.1698	0.	0.2963
10	C.0957	0.0586	0.0247	0.0216	0.0185	0.0093	C.0123	0.	0.24C7
20	0.1142	0.0648	C.0154	0.0123	0.	0.	0.0031	0.	0.2099
30	0.1111	0.0556	0.0401	0.0154	0.	0.	C.0062	0.	0.2284
40	0.0123	0.0C31	0.	0.C031	0.0031	0.	C.	0.	0.0216
50	C.	0.	0.	0.	0.	0.	C.	0.	0.
60	0.	0.	0.	0.	0.	0.	0.	0.	0.
70	0.0C31	0.	0.	0.	0.	0.	0.	0.	0.0031
80	0.	0.	0.	0.	0.	0.	C.	0.	0.
90	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	14	10	1	1	0	1	0	0	27	1.74	1.13
30	19	8	1	5	1	1	2	0	37	2.24	1.77
60	10	3	3	0	1	0	0	0	17	1.76	1.15
90	7	4	2	0	0	0	1	0	14	2.00	1.62
120	12	4	1	0	0	1	0	0	18	1.61	1.24
150	6	0	1	1	1	0	0	0	9	2.00	1.58
180	5	0	0	0	0	0	1	0	6	2.00	2.45
210	8	4	6	0	0	0	0	0	18	1.89	0.90
240	13	8	4	0	0	0	1	0	26	1.85	1.29
270	6	2	1	0	0	0	0	0	9	1.44	0.73
300	7	3	0	0	0	1	0	0	11	1.73	1.49
330	4	8	1	0	0	0	0	0	13	1.77	0.60
360	5	2	3	5	0	0	0	0	15	2.53	1.30
390	0	0	0	0	0	0	0	0	0	0.	0.
420	1	0	0	0	0	0	0	0	1	1.00	0.
450	0	0	0	0	0	0	0	0	0	0.	0.
480	2	0	1	4	0	0	0	0	7	3.00	1.41
510	0	0	2	1	1	0	0	0	4	3.75	0.96
540	0	0	0	0	0	0	0	0	0	0.	0.
570	0	0	0	0	0	0	0	0	0	0.	0.
600	0	0	0	0	0	0	0	0	0	0.	0.
630	0	0	0	0	0	0	0	0	0	0.	0.
660	0	0	0	0	0	0	0	0	0	0.	0.
690	0	0	0	0	0	0	0	0	0	0.	0.
720	0	0	0	0	0	0	0	0	0	0.	0.
750	0	0	0	0	0	0	0	0	0	0.	0.
780	0	0	0	0	0	0	0	0	0	0.	0.
810	0	0	0	0	0	0	0	0	0	0.	0.
840	0	0	0	0	0	0	0	0	0	0.	0.
870	0	0	0	0	0	0	0	0	0	0.	0.
900	0	0	0	0	0	0	0	0	0	0.	0.
930	0	0	0	0	0	0	0	0	0	0.	0.
960	0	0	0	0	0	0	0	0	0	0.	0.
990	0	0	0	0	0	0	0	0	0	0.	0.
1020	0	0	0	0	0	0	0	0	0	0.	0.
1050	0	0	0	0	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0	0	0	0	0.	0.
1140	0	0	0	0	0	0	0	0	0	0.	0.
1170	0	0	0	0	0	0	0	0			
TOTAL	119	56	27	17	4	4	5	0			
AVE	166.76	172.50	239.44	281.47	202.50	127.50	129.00	0.	184.14		
S D	206.62	216.08	281.94	357.82	316.36	196.33	169.41	0.	230.00		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL
C	0.0603	0.0431	0.0043	0.C043	0.	0.0043	0.	0.	0.1164
30	0.0819	0.0345	0.0043	0.C216	0.0043	0.0043	0.0086	0.	0.1595
60	C.0431	0.0129	0.0129	0.	0.0043	0.	0.	C.	0.0733
90	0.0302	0.0172	0.0086	0.	0.	0.	0.0043	0.	0.0603
120	0.0517	0.0172	0.0043	0.	0.	0.0C43	0.	0.	0.0776
150	0.0259	0.	0.0043	0.CC43	0.0C43	0.	0.	0.	0.0388
180	0.0216	0.	0.	0.	0.	C.	C.0043	0.	0.0259
210	0.0345	0.0172	0.0259	0.	0.	0.	0.	0.	0.0776
240	C.0560	C.0345	C.0172	0.	0.	0.	0.0043	0.	0.1121
270	C.0259	0.0086	0.0043	0.	0.	0.	0.	0.	0.0388
300	C.0302	0.0129	0.	0.	0.	0.0043	0.	0.	0.0474
330	C.0172	0.0345	0.0043	0.	0.	C.	0.	0.	0.0560
360	0.0216	0.0086	0.C129	0.C216	0.	0.	C.	0.	0.0647
390	0.	0.	0.	0.	0.	0.	0.	0.	0.
420	0.0043	0.	0.	0.	0.	0.	C.	0.	0.0043
450	0.	0.	0.	0.	0.	0.	C.	0.	0.
480	0.0086	0.	0.0043	0.0172	0.	0.	0.	0.	0.0302
510	0.	0.	0.0086	0.0043	0.0043	0.	C.	0.	0.0172
540	0.	0.	0.	0.	0.	0.	0.	0.	0.
570	0.	0.	0.	0.	0.	0.	C.	0.	0.
600	0.	0.	0.	0.	0.	0.	0.	0.	0.
630	0.	0.	0.	0.	0.	0.	0.	0.	0.
660	0.	0.	0.	0.	0.	0.	0.	0.	0.
690	0.	0.	0.	0.	0.	0.	C.	0.	0.
720	0.	0.	0.	0.	0.	0.	0.	0.	0.
750	0.	0.	0.	0.	0.	0.	0.	0.	0.
780	0.	0.	0.	0.	0.	0.	0.	0.	0.
810	0.	0.	0.	0.	0.	0.	0.	0.	0.
840	0.	0.	0.	0.	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.	0.	0.	0.	0.
960	C.	0.	0.	0.	0.	C.	0.	0.	0.
990	0.	0.	0.	0.	0.	0.	0.	0.	0.
1020	0.	0.	0.	0.	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.	C.	0.	0.	0.
1140	C.	0.	0.	0.	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.	0.	0.	C.	0.	0.
TOTAL	C.5129	0.2414	0.1164	0.0733	0.0172	0.0172	0.0216	0.	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	6	3	0	1	0	0	5	0	15	3.40	2.75
3	93	48	21	2C	6	14	47	0	249	3.11	2.32
4	22	13	11	2	2	0	10	0	60	2.82	2.14
5	0	0	0	0	0	0	0	0	0	0.	0.
6	0	C	0	C	0	0	0	0	0	0.	G.
AVE	3.63	3.66	3.84	3.54	3.75	3.5C	3.58	0.	3.64		
S D	3.68	3.72	3.93	3.64	4.00	3.62	3.64	C.	3.67		

FRACTICN OF SHELTERS PFR PF CATEGORY

LOG FLOCR AREA	1	2	3	4	5	6	7	8	TOTAL
2	C.0185	0.0C93	0.	0.0C31	0.	0.	0.0154	0.	0.0463
3	0.2870	0.1481	0.0648	0.C617	0.0185	0.0432	0.1451	0.	0.7685
4	0.0679	0.0401	0.0340	0.CC62	0.C062	0.	C.C309	0.	0.1852
5	0.	0.	0.	0.	0.	C.	0.	0.	0.
6	C.	0.	0.	0.	0.	0.	C.	C.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
28	14	13	12	5	5	20	0	97	3.48	2.28

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL
0.0864	0.0432	0.0401	0.0370	0.0154	0.0154	0.0617	0.	0.2994

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
50	4	1	0	0	0	1	1	0	7	2.71	2.63
75	12	12	0	0	0	2	1	0	27	2.04	1.63
100	55	19	12	5	0	2	5	0	98	2.00	1.59
125	6	8	2	8	0	0	6	0	30	3.40	2.13
150	14	5	3	1	2	1	17	0	43	4.00	2.71
175	13	5	3	2	1	0	9	0	33	3.27	2.53
200	5	5	4	2	3	3	4	0	26	3.69	2.17
225	1	1	0	2	0	1	4	0	9	5.00	2.35
250	5	5	1	1	0	0	2	0	14	2.57	2.06
275	1	2	3	2	0	0	4	0	12	4.17	2.25
300	3	0	1	0	1	3	3	0	11	4.55	2.54
325	0	0	0	0	1	0	1	0	2	6.00	1.41
350	0	0	0	0	0	0	0	0	0	0.	0.
375	0	0	0	0	0	0	1	0	1	7.00	0.
400	0	0	0	0	0	0	1	0	1	7.00	0.
425	1	0	1	0	0	0	0	0	2	2.00	1.41
450	0	1	0	0	0	0	0	0	1	2.00	0.
475	1	0	2	0	0	1	3	0	7	4.86	2.48
AVE	147.00	152.34	199.22	171.20	225.00	208.93	209.68	0.	171.53		
S D	162.66	169.07	229.66	184.31	247.46	246.56	231.45	0.	191.60		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.0123	0.0031	0.	0.	0.	0.0031	0.0031	0.	0.0216
75	0.0370	0.0370	0.	0.	0.	0.0062	0.0031	0.	0.0833
100	0.1698	0.0586	0.0370	0.0154	0.	0.0062	0.0154	0.	0.3025
125	0.0185	0.0247	0.0062	0.0247	0.	0.	0.0185	0.	0.0926
150	0.0432	0.0154	0.0093	0.0031	0.0062	0.0031	0.0525	0.	0.1327
175	0.0401	0.0154	0.0093	0.0062	0.0031	0.	0.0278	0.	0.1019
200	0.0154	0.0154	0.0123	0.0062	0.0093	0.0093	0.0123	0.	0.0802
225	0.0031	0.0031	0.	0.0062	0.	0.0031	0.0123	0.	0.0278
250	0.0154	0.0154	0.0031	0.0031	0.	0.	0.0062	0.	0.0432
275	0.0031	0.0062	0.0093	0.0062	0.	0.	0.0123	0.	0.0370
300	0.0093	0.	0.0031	0.	0.0031	0.0093	0.0093	0.	0.0340
325	0.	0.	0.	0.	0.0031	0.	0.0031	0.	0.0062
350	0.	0.	0.	0.	0.	0.	0.	0.	0.
375	0.	0.	0.	0.	0.	0.	0.0031	0.	0.0031
400	0.	0.	0.	0.	0.	0.	0.0031	0.	0.0031
425	0.0031	0.	0.0031	0.	0.	0.	0.	0.	0.0062
450	0.	0.0031	0.	0.	0.	0.	0.	0.	0.0031
475	0.0031	0.	0.0062	0.	0.	0.0031	0.0093	0.	0.0216

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	19	17	3	8	2	4	3	0	56	2.66	1.84
2	49	26	20	13	4	1	10	0	123	2.51	1.79
3	3	3	0	1	0	1	3	0	11	3.64	2.62
4	45	17	9	1	1	5	36	0	114	3.48	2.65
5	5	1	0	0	1	3	10	0	20	5.00	2.64
AVE	2.74	2.36	2.47	1.78	2.37	3.14	3.65	0.	2.75		
S D	3.01	2.66	2.70	1.96	2.89	3.63	3.83	0.	3.03		

FRACTION OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL
1	0.0586	0.0525	0.0093	0.0247	0.0062	0.0123	C.0093	0.	0.1728
2	C.1512	0.0802	0.0617	0.0401	0.0123	0.0C31	0.0309	0.	0.3796
3	C.0093	0.0093	0.	0.0031	0.	0.0031	0.C093	0.	0.0340
4	0.1389	0.0525	0.0278	0.CC31	0.0031	0.C154	0.1111	0.	0.3519
5	C.0154	0.0031	0.	0.	0.C031	0.0093	C.0309	0.	C.0617

VIII. SHELTER STATISTICS FOR PF CLASS 8 BUILDINGS

Shelters contributing to these tabulations are in buildings containing at least one shelter rated in PF Category 8 but none higher. There are 132 buildings in this category. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	11	9	5	5	8	11	10	175	234	7.01	2.03
1	71	36	13	8	7	4	2	7	148	2.32	1.90
2	43	43	27	18	16	6	0	2	155	2.67	1.58
3	38	26	14	16	18	8	1	2	123	2.90	1.82
4	28	24	7	10	11	12	2	2	96	3.06	2.00
5	34	24	9	4	4	8	1	0	84	2.38	1.69
6	26	17	9	5	4	5	1	0	67	2.45	1.66
7	18	18	8	4	4	4	2	0	58	2.62	1.73
8	17	17	8	1	1	5	4	0	53	2.68	1.93
9	6	14	8	3	1	3	4	1	40	3.22	2.02
10	7	10	4	4	2	2	3	3	35	3.49	2.32
11	7	8	4	3	3	1	2	4	32	3.56	2.42
12	6	7	4	2	4	1	2	2	28	3.43	2.23
13	0	8	5	2	3	1	0	1	20	3.40	1.67
14	3	2	2	1	4	0	0	1	13	3.46	2.11
15	3	1	0	1	2	2	0	1	10	3.90	2.51
16	0	5	0	1	1	2	0	1	10	3.90	2.23
17	0	2	2	0	2	2	0	1	9	4.44	2.07
18	0	1	3	1	0	2	1	1	9	4.67	2.12
19	0	4	0	1	0	3	1	0	9	4.11	2.15
20	0	3	4	1	1	0	0	0	9	3.00	1.00
21	1	1	2	2	1	0	0	0	7	3.14	1.35
22	3	0	1	3	0	0	0	0	7	2.57	1.51
23	1	0	0	3	0	0	0	0	4	3.25	1.50
24	0	0	0	3	0	0	0	0	3	4.00	0.
25	0	0	0	3	0	0	0	0	3	4.00	0.
26	0	0	0	3	0	0	0	0	3	4.00	0.
27	0	0	0	3	0	0	0	0	3	4.00	0.
28	0	0	0	2	1	0	0	0	3	4.33	0.58
29	0	0	0	2	1	0	0	0	3	4.33	0.58
30	0	0	0	1	2	0	0	0	3	4.67	0.58
31	0	0	0	0	3	0	0	0	3	5.00	0.
32	0	0	0	0	3	0	0	0	3	5.00	0.
33	0	0	0	0	3	0	0	0	3	5.00	0.
34	0	0	0	0	3	0	0	0	3	5.00	0.
35	0	0	0	0	3	0	0	0	3	5.00	0.
36	0	0	0	1	2	0	0	0	3	4.67	0.58
37	0	0	3	0	0	0	0	0	3	3.00	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	323	280	142	117	118	82	36	204			
AVE	4.46	5.76	7.01	5.68	10.40	6.07	6.08	1.10	5.65		
S D	5.94	7.42	9.89	13.61	15.45	8.12	8.10	3.63	8.78		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0084	0.0069	0.0038	0.0038	0.0061	0.0084	0.0077	0.1344	0.1797
1	0.0545	0.0276	0.0100	0.0061	0.0054	0.0039	0.0015	0.0054	0.1137
2	0.0330	0.0330	0.0207	0.0138	0.0123	0.0046	0.	0.0015	0.1190
3	0.0292	0.0200	0.0108	0.0123	0.0138	0.0061	0.0008	0.0015	0.0945
4	0.0215	0.0184	0.0054	0.0077	0.0084	0.0092	0.0015	0.0015	0.0737
5	0.0261	0.0184	0.0069	0.0031	0.0031	0.0061	0.0008	0.	0.0645
6	0.0200	0.0131	0.0069	0.0038	0.0031	0.0038	0.0008	0.	0.0515
7	0.0138	0.0138	0.0061	0.0031	0.0031	0.0031	0.0015	0.	0.0445
8	0.0131	0.0131	0.0061	0.0008	0.0008	0.0038	0.0031	0.	0.0407
9	0.0046	0.0108	0.0061	0.0023	0.0008	0.0023	0.0031	0.0008	0.0307
10	0.0054	0.0077	0.0031	0.0031	0.0015	0.0015	0.0023	0.0023	0.0269
11	0.0054	0.0061	0.0031	0.0023	0.0023	0.0008	0.0015	0.0031	0.0246
12	0.0046	0.0054	0.0031	0.0015	0.0031	0.0008	0.0015	0.0015	0.0215
13	0.	0.0061	0.0038	0.0015	0.0023	0.0008	0.	0.0008	0.0154
14	0.0023	0.0015	0.0015	0.0008	0.0031	0.	0.	0.0008	0.0100
15	0.0023	0.0008	0.	0.0008	0.0015	0.0015	0.	0.0008	0.0077
16	0.	0.0038	0.	0.0008	0.0008	0.0015	0.	0.0008	0.0077
17	0.	0.0015	0.0015	0.	0.0015	0.0015	0.	0.0008	0.0069
18	0.	0.0008	0.0023	0.0008	0.	0.0015	0.0008	0.0008	0.0069
19	0.	0.0031	0.	0.0008	0.	0.0023	0.0008	0.	0.0069
20	0.	0.0023	0.0031	0.0008	0.0008	0.	0.	0.	0.0069
21	0.0008	0.0008	0.0015	0.0015	0.0008	0.	0.	0.	0.0054
22	0.0023	0.	0.0008	0.0023	0.	0.	0.	0.	0.0054
23	0.0008	0.	0.	0.0023	0.	0.	0.	0.	0.0031
24	0.	0.	0.	0.0023	0.	0.	0.	0.	0.0023
25	0.	0.	0.	0.0023	0.	0.	0.	0.	0.0023
26	0.	0.	0.	0.0023	0.	0.	0.	0.	0.0023
27	0.	0.	0.	0.0023	0.	0.	0.	0.	0.0023
28	0.	0.	0.	0.0015	0.0008	0.	0.	0.	0.0023
29	0.	0.	0.	0.0015	0.0008	0.	0.	0.	0.0023
30	0.	0.	0.	0.0008	0.0015	0.	0.	0.	0.0023
31	0.	0.	0.	0.	0.0023	0.	0.	0.	0.0023
32	0.	0.	0.	0.	0.0023	0.	0.	0.	0.0023
33	0.	0.	0.	0.	0.0023	0.	0.	0.	0.0023
34	0.	0.	0.	0.	0.0023	0.	0.	0.	0.0023
35	0.	0.	0.	0.	0.0023	0.	0.	0.	0.0023
36	0.	0.	0.	0.0008	0.0015	0.	0.	0.	0.0023
37	0.	0.	0.0023	0.	0.	0.	0.	0.	0.0023
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.2481	0.2151	0.1091	0.0899	0.0906	0.0630	0.0276	0.1567	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	28	25	11	13	2C	23	11	174	305	6.13	2.55
10	99	80	57	47	42	25	15	23	388	3.27	2.10
20	113	122	49	40	44	28	8	4	408	2.79	1.75
30	35	38	15	13	8	3	1	2	115	2.51	1.59
40	28	12	7	4	4	1	1	1	58	2.24	1.68
50	16	2	1	C	C	2	0	0	21	1.67	1.53
60	2	0	0	0	0	C	C	0	2	1.00	0.
70	2	1	2	C	0	0	0	0	5	2.00	1.00
80	0	0	0	0	C	C	0	0	0	0.	0.
90	0	0	0	C	0	C	0	C	0	0.	0.
AVE	25.06	22.96	22.39	2C.56	19.41	17.68	15.56	7.01	19.85		
S D	28.49	25.22	25.34	22.73	21.75	20.92	18.43	9.02	23.33		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0215	0.0192	0.0084	0.010[illegible]	0.0154	0.0177	0.0084	0.1336	0.2343
10	0.0760	0.0614	0.0438	0.0361	0.0323	0.0192	0.0115	0.0177	0.2980
20	0.0868	0.0937	0.0376	0.0307	0.0338	0.0215	0.0061	0.0031	0.3134
30	0.0269	0.0292	0.0115	0.0100	0.0061	0.0023	0.0008	0.0015	0.0883
40	0.0215	0.0092	0.0054	0.0031	0.0031	0.0008	0.0008	0.0008	0.0445
50	0.0123	0.0015	0.0008	0.	0.	0.0015	0.	0.	0.0161
60	0.0015	0.	0.	0.	0.	0.	0.	0.	0.0015
70	0.0015	0.0008	0.0015	0.	0.	0.	0.	0.	0.0038
80	0.	0.	0.	0.	0.	0.	0.	0.	0.
90	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	26	28	27	15	23	21	8	7	155	3.72	2.06
30	33	45	25	30	23	20	16	14	206	3.77	2.17
60	31	38	13	7	7	9	0	1	106	2.56	1.64
90	37	36	15	7	8	4	2	1	111	2.44	1.60
120	30	36	13	8	2	2	0	1	92	2.21	1.31
150	22	16	7	3	3	7	0	0	58	2.48	1.71
180	34	28	10	6	11	4	0	2	95	2.52	1.72
210	28	9	8	1	0	0	0	0	46	1.61	0.86
240	16	13	2	3	5	2	0	0	41	2.37	1.59
270	10	6	14	23	16	0	0	2	71	3.55	1.52
300	15	7	0	0	0	0	0	0	22	1.32	0.48
330	3	0	2	8	10	2	0	0	25	4.12	1.39
360	7	0	0	0	0	0	0	0	7	1.00	0.
390	5	0	0	0	0	0	0	0	5	1.00	0.
420	3	2	0	0	0	0	0	0	5	1.40	0.55
450	3	2	0	0	2	0	0	0	7	2.43	1.81
480	3	1	0	0	0	0	0	1	5	2.60	3.05
510	2	0	0	0	0	0	0	0	2	1.00	0.
540	0	0	0	0	0	0	0	0	0	0.	0.
570	0	0	0	0	0	0	0	0	0	0.	0.
600	0	0	0	0	0	0	0	0	0	0.	0.
630	0	2	0	0	0	0	0	0	2	2.00	0.
660	0	0	0	0	0	0	0	0	0	0.	0.
690	0	0	0	0	0	0	0	0	0	0.	0.
720	0	0	0	0	0	0	0	0	0	0.	0.
750	0	0	0	0	0	0	0	0	0	0.	0.
780	0	0	0	0	0	0	0	0	0	0.	0.
810	0	0	0	0	0	0	0	0	0	0.	0.
840	0	0	0	0	0	0	0	0	0	0.	0.
870	0	0	0	0	0	0	0	0	0	0.	0.
900	0	0	0	0	0	0	0	0	0	0.	0.
930	0	0	0	0	0	0	0	0	0	0.	0.
960	0	0	0	0	0	0	0	0	0	0.	0.
990	4	2	0	0	0	0	0	0	6	1.33	0.52
1020	0	0	0	0	0	0	0	0	0	0.	0.
1050	0	0	0	0	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0	0	0	0	0.	0.
1140	0	0	0	0	0	0	0	0	0	0.	0.
1170	0	0	0	1	0	0	0	0	1	4.00	0.
TOTAL	312	271	137	112	110	71	26	29			
AVE	177.21	136.11	117.04	152.41	144.27	80.49	40.38	86.38	140.84		
S D	230.73	185.15	149.12	214.49	190.68	112.57	47.41	139.91	192.16		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL
0	0.0243	0.0262	0.0253	0.0140	0.0215	0.0197	0.0075	0.0066	0.1451
30	0.0309	0.0421	0.0234	0.0281	0.0215	0.0187	0.0150	0.0131	0.1929
60	0.0290	0.0356	0.0122	0.0066	0.0066	0.0084	0.	0.0009	0.0993
90	0.0346	0.0337	0.0150	0.0066	0.0075	0.0037	0.0019	0.0009	0.1039
120	0.0281	0.0337	0.0122	0.0075	0.0019	0.0019	0.	0.0009	0.0861
150	0.0206	0.0150	0.0066	0.0028	0.0028	0.0066	0.	0.	0.0543
180	0.0318	0.0262	0.0094	0.0056	0.0103	0.0037	0.	0.0019	0.0890
210	0.0262	0.0094	0.0075	0.0009	0.	0.	0.	0.	0.0431
240	0.0150	0.0122	0.0019	0.0028	0.0047	0.0019	0.	0.	0.0384
270	0.0094	0.0056	0.0131	0.0215	0.0150	0.	0.	0.0019	0.0665
300	0.0140	0.0066	0.	0.	0.	0.	0.	0.	0.0206
330	0.0028	0.	0.0019	0.0075	0.0094	0.0019	0.	0.	0.0234
360	0.0066	0.	0.	0.	0.	0.	0.	0.	0.0066
390	0.0047	0.	0.	0.	0.	0.	0.	0.	0.0047
420	0.0028	0.0019	0.	0.	0.	0.	0.	0.	0.0047
450	0.0028	0.0019	0.	0.	0.0019	0.	0.	0.	0.0066
480	0.0028	0.0009	0.	0.	0.	0.	0.	0.0009	0.0047
510	0.0019	0.	0.	0.	0.	0.	0.	0.	0.0019
540	0.	0.	0.	0.	0.	0.	0.	0.	0.
570	0.	0.	0.	0.	0.	0.	0.	0.	0.
600	0.	0.	0.	0.	0.	0.	0.	0.	0.
630	0.	0.0019	0.	0.	0.	0.	0.	0.	0.0019
660	0.	0.	0.	0.	0.	0.	0.	0.	0.
690	0.	0.	0.	0.	0.	0.	0.	0.	0.
720	0.	0.	0.	0.	0.	0.	0.	0.	0.
750	0.	0.	0.	0.	0.	0.	0.	0.	0.
780	0.	0.	0.	0.	0.	0.	0.	0.	0.
810	0.	0.	0.	0.	0.	0.	0.	0.	0.
840	0.	0.	0.	0.	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.	0.	0.	0.	0.
960	0.	0.	0.	0.	0.	0.	0.	0.	0.
990	0.0037	0.0019	0.	0.	0.	0.	0.	0.	0.0056
1020	0.	0.	0.	0.	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.	0.	0.	0.	0.
1140	0.	0.	0.	0.	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.0009	0.	0.	0.	0.	0.0009
TOTAL	0.2921	0.2537	0.1283	0.1049	0.1030	0.0665	0.0243	0.0272	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	10	3	2	0	1	2	3	8	29	4.28	3.08
3	260	219	98	69	59	36	19	131	891	3.32	2.46
4	52	58	42	48	58	44	14	64	380	4.34	2.34
5	1	0	0	0	0	0	0	1	2	4.50	4.95
6	0	0	0	0	0	0	0	0	0	0.	0.
AVE	3.64	3.70	3.78	3.91	3.98	4.01	3.81	3.78	3.77		
S D	3.67	3.73	3.83	3.96	4.03	4.07	3.91	3.83	3.81		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL
2	0.0077	0.0023	0.0015	0.	0.0008	0.0015	0.0023	0.0061	0.0223
3	0.1997	0.1682	0.0753	0.0530	0.0453	0.0276	0.0146	0.1006	0.6843
4	0.0399	0.0445	0.0323	0.0369	0.0445	0.0338	0.0108	0.0492	0.2919
5	0.0008	0.	0.	0.	0.	0.	0.	0.0008	0.0015
6	0.	0.	0.	0.	0.	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
27	33	20	16	22	10	5	34	167	4.16	2.51

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL
0.0207	0.0253	0.0154	0.C123	0.0169	0.0077	C.0038	0.0261	0.1283

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	C	0	0	0	0	0	0	0	0.	0.
25	1	0	0	C	0	0	0	0	1	1.00	0.
50	5	2	0	C	C	0	0	0	7	1.29	0.49
75	53	44	16	13	10	4	1	1	142	2.32	1.51
100	118	104	60	56	46	24	15	24	447	3.13	2.04
125	43	57	33	19	24	30	8	20	234	3.62	2.22
150	44	39	17	15	19	13	3	35	185	3.82	2.58
175	21	6	3	2	1	1	4	15	53	3.94	3.09
200	13	12	4	4	3	2	1	35	74	5.12	3.00
225	14	10	4	1	5	0	1	3	38	2.79	2.18
250	2	1	1	2	3	2	0	12	23	6.00	2.47
275	3	C	2	1	1	0	1	7	15	5.40	2.95
300	2	C	2	2	2	4	0	15	27	6.30	2.28
325	1	2	0	C	2	0	1	3	9	5.11	2.85
350	0	1	0	C	0	0	0	4	5	6.80	2.68
375	0	C	0	1	C	0	0	4	5	7.20	1.79
400	1	C	0	1	1	1	1	5	10	6.30	2.36
425	0	1	0	C	1	C	0	4	6	6.50	2.51
450	0	0	0	C	0	0	0	5	5	8.00	0.
475	2	1	0	C	C	1	0	12	16	6.62	2.68
AVE	139.59	136.16	135.74	138.35	149.79	153.35	155.56	235.42	155.57		
S D	151.09	145.94	143.31	149.91	163.84	168.74	172.06	260.41	173.24		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.0008	0.	0.	0.	0.	0.	0.	0.	0.0008
50	0.0038	0.0015	0.	0.	0.	0.	0.	0.	0.0054
75	0.0407	0.0338	0.0123	0.0100	0.0077	0.0031	0.0008	0.0008	0.1091
100	0.0906	0.0799	0.0461	0.0430	0.0353	0.0184	0.0115	0.0184	0.3433
125	0.0330	0.0438	0.0253	0.0146	0.0184	0.0230	0.0061	0.0154	0.1797
150	0.0338	0.0300	0.0131	0.0115	0.0146	0.0100	0.0023	0.0269	0.1421
175	0.0161	0.0046	0.0023	0.0015	0.0008	0.0008	0.0031	0.0115	0.0407
200	0.0100	0.0092	0.0031	0.0031	0.0023	0.0015	0.0008	0.0269	0.0568
225	0.0108	0.0077	0.0031	0.0003	0.0038	0.	0.0008	0.0023	0.0292
250	0.0015	0.0008	0.0008	0.0015	0.0023	0.0015	0.	0.0092	0.0177
275	0.0023	0.	0.0015	0.0003	0.0008	0.	0.0008	0.0054	0.0115
300	0.0015	0.	0.0015	0.0015	0.0015	0.0031	0.	0.0115	0.0207
325	0.0008	0.0015	0.	0.	0.0015	0.	0.0008	0.0023	0.0069
350	0.	0.0008	0.	0.	0.	0.	0.	0.0031	0.0038
375	0.	0.	0.	0.0002	0.	0.	0.	0.0031	0.0038
400	0.0008	0.	0.	0.0008	0.0008	0.0008	0.0008	0.0038	0.0077
425	0.	0.0008	0.	0.	0.0008	0.	0.	0.0031	0.0046
450	0.	0.	0.	0.	0.	0.	0.	0.0038	0.0038
475	0.0015	0.0008	0.	0.	0.	0.0008	0.	0.0092	0.0123

DOSE SOURCE

I=1 NO SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 40 PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PERCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	58	40	17	17	6	1	1	163	303	5.29	3.06
2	186	191	98	83	74	57	22	12	723	2.98	1.85
3	17	22	9	4	25	9	4	0	90	3.46	1.90
4	62	24	15	13	13	14	6	29	176	3.58	2.65
5	C	3	3	C	C	1	3	0	10	4.20	2.25
AVE	2.26	2.14	2.22	2.11	2.38	2.48	2.67	1.49	2.13		
S D	2.46	2.29	2.39	2.26	2.51	2.63	2.91	1.82	2.33		

FRACTION OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL
1	C.C445	0.0307	C.C131	0.C131	0.C046	0.00C8	C.0008	0.1252	0.2327
2	C.1429	0.1467	C.0753	0.C637	C.C568	0.0438	C.0169	0.C092	0.5553
3	C.C131	0.0169	0.C069	0.CC31	0.C192	C.CC69	C.0031	0.	0.0691
4	C.C476	0.0194	C.C115	0.C10C	0.C150	C.0108	0.0C45	0.C223	0.1352
5	C.	0.0023	0.C023	0.	C.	C.0CC8	C.0C23	0.	0.0077

IX. TOTAL SHELTER STATISTICS FOR ALL PF CLASSES

These composite tabulations include all PF category shelters that are contained in the 1541 sample buildings. Definitions of category headings such as Contaminated Plane Width and Percent Aperture are found in Section IV. B. 2. of Chapter 3.

NUMBER OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	491	371	169	158	138	122	67	175	1691	3.35	2.36
1	453	180	50	3C	22	17	6	7	765	1.82	1.39
2	351	136	50	31	22	9	1	2	602	1.80	1.25
3	186	81	25	22	22	10	1	2	349	2.02	1.47
4	114	35	10	13	13	14	2	2	203	2.19	1.77
5	66	32	15	6	5	8	1	0	133	2.10	1.51
6	44	26	9	6	5	5	1	0	96	2.18	1.54
7	30	24	8	5	4	4	2	0	77	2.34	1.62
8	27	21	10	1	1	5	4	0	69	2.41	1.79
9	13	17	10	3	1	3	4	1	52	2.85	1.93
10	12	11	7	5	2	2	3	3	45	3.16	2.19
11	10	10	7	4	3	1	2	4	41	3.27	2.26
12	10	9	6	3	4	1	2	2	37	3.08	2.10
13	2	12	6	3	3	1	0	1	28	3.04	1.60
14	6	5	3	1	4	0	0	1	20	2.85	1.93
15	9	2	0	1	2	2	0	1	17	2.76	2.36
16	0	6	0	1	1	2	0	1	11	3.73	2.20
17	0	3	2	0	2	2	0	1	10	4.20	2.10
18	0	2	3	1	0	2	1	1	10	4.40	2.17
19	0	5	C	1	C	3	1	0	10	3.90	2.13
20	1	3	4	1	1	0	0	0	10	2.80	1.14
21	1	1	2	2	1	0	0	0	7	3.14	1.35
22	3	0	1	3	0	0	0	0	7	2.57	1.51
23	1	0	0	3	C	0	0	0	4	3.25	1.50
24	0	0	0	3	0	0	0	0	3	4.00	0.
25	0	0	0	3	0	0	0	0	3	4.00	0.
26	0	0	0	3	C	0	0	0	3	4.00	0.
27	0	0	0	3	C	0	0	0	3	4.00	0.
28	0	0	0	2	1	0	0	0	3	4.33	0.58
29	0	0	0	2	1	0	0	0	3	4.33	0.58
30	0	0	0	1	2	0	0	0	3	4.67	0.58
31	0	0	0	0	3	0	0	0	3	5.00	0.
32	0	0	0	0	3	0	0	0	3	5.00	0.
33	0	0	0	C	3	0	0	0	3	5.00	0.
34	0	0	0	C	3	0	0	0	3	5.00	0.
35	0	0	0	0	3	C	0	0	3	5.00	0.
36	0	0	0	1	2	0	0	0	3	4.67	0.58
37	0	0	3	C	0	0	0	0	3	3.00	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	C	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	C	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	1830	992	400	322	277	213	98	204			
AVE	2.20	2.60	3.25	3.98	4.64	2.49	2.30	1.10	2.64		
S D	3.55	4.63	6.30	8.34	10.09	5.05	4.87	3.63	5.28		

FRACTION OF SHELTERS PER PF CATEGORY

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.1132	0.0856	0.0390	0.0364	0.0318	0.0281	0.0155	0.0404	0.3900
1	0.1045	0.0415	0.0115	0.0069	0.0051	0.0039	0.0014	0.0016	0.1764
2	0.0810	0.0314	0.0115	0.0071	0.0051	0.0021	0.0002	0.0005	0.1388
3	0.0429	0.0187	0.0058	0.0051	0.0051	0.0023	0.0002	0.0005	0.0805
4	0.0263	0.0081	0.0023	0.0030	0.0030	0.0032	0.0005	0.0005	0.0468
5	0.0152	0.0074	0.0035	0.0014	0.0012	0.0018	0.0002	0.	0.0307
6	0.0101	0.0060	0.0021	0.0014	0.0012	0.0012	0.0002	0.	0.0221
7	0.0069	0.0055	0.0018	0.0012	0.0009	0.0009	0.0005	0.	0.0178
8	0.0062	0.0048	0.0023	0.0002	0.0002	0.0012	0.0009	0.	0.0159
9	0.0030	0.0039	0.0023	0.0007	0.0002	0.0007	0.0009	0.0002	0.0120
10	0.0028	0.0025	0.0016	0.0012	0.0005	0.0005	0.0007	0.0007	0.0104
11	0.0023	0.0023	0.0016	0.0009	0.0007	0.0002	0.0005	0.0009	0.0095
12	0.0023	0.0021	0.0014	0.0007	0.0009	0.0002	0.0005	0.0005	0.0085
13	0.0005	0.0028	0.0014	0.0007	0.0007	0.0002	0.	0.0002	0.0065
14	0.0014	0.0012	0.0007	0.0002	0.0009	0.	0.	0.0002	0.0046
15	0.0021	0.0005	0.	0.0002	0.0005	0.0005	0.	0.0002	0.0039
16	0.	0.0014	0.	0.0002	0.0002	0.0005	0.	0.0002	0.0025
17	0.	0.0007	0.0005	0.	0.0005	0.0005	0.	0.0002	0.0023
18	0.	0.0005	0.0007	0.0002	0.	0.0005	0.0002	0.0002	0.0023
19	0.	0.0012	0.	0.0002	0.	0.0007	0.0002	0.	0.0023
20	0.0002	0.0007	0.0009	0.0002	0.0002	0.	0.	0.	0.0023
21	0.0002	0.0002	0.0005	0.0005	0.0002	0.	0.	0.	0.0016
22	0.0007	0.	0.0002	0.0007	0.	0.	0.	0.	0.0016
23	0.0002	0.	0.	0.0007	0.	0.	0.	0.	0.0009
24	0.	0.	0.	0.0007	0.	0.	0.	0.	0.0007
25	0.	0.	0.	0.0007	0.	0.	0.	0.	0.0007
26	0.	0.	0.	0.0007	0.	0.	0.	0.	0.0007
27	0.	0.	0.	0.0007	0.	0.	0.	0.	0.0007
28	0.	0.	0.	0.0005	0.0002	0.	0.	0.	0.0007
29	0.	0.	0.	0.0005	0.0002	0.	0.	0.	0.0007
30	0.	0.	0.	0.0002	0.0005	0.	0.	0.	0.0007
31	0.	0.	0.	0.	0.0007	0.	0.	0.	0.0007
32	0.	0.	0.	0.	0.0007	0.	0.	0.	0.0007
33	0.	0.	0.	0.	0.0007	0.	0.	0.	0.0007
34	0.	0.	0.	0.	0.0007	0.	0.	0.	0.0007
35	0.	0.	0.	0.	0.0007	0.	0.	0.	0.0007
36	0.	0.	0.	0.0002	0.0005	0.	0.	0.	0.0007
37	0.	0.	0.0007	0.	0.	0.	0.	0.	0.0007
38	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL	0.4220	0.2288	0.0923	0.0743	0.0639	0.0491	0.0226	0.0470	

NUMBER OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	436	340	148	129	129	127	66	174	1549	3.45	2.41
10	596	263	123	100	71	40	19	23	1235	2.27	1.71
20	472	255	78	62	55	40	9	4	975	2.13	1.53
30	205	100	39	21	12	3	3	2	385	1.87	1.28
40	77	22	9	7	6	1	1	1	124	1.83	1.40
50	29	3	1	2	4	2	0	0	41	1.90	1.62
60	7	5	0	1	0	0	0	0	13	1.62	0.87
70	6	4	2	0	0	0	0	0	12	1.67	0.78
80	2	0	0	0	0	0	0	0	2	1.00	0.
90	0	0	0	0	0	0	0	0	0	0.	0.
AVE	19.80	17.44	16.27	15.28	14.42	11.71	10.10	7.01	17.04		
S D	23.53	21.23	20.05	18.90	18.31	15.19	13.34	9.02	20.99		

FRACTION OF SHELTERS PER PF CATEGORY

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.1006	0.0784	0.0341	0.0298	0.0298	0.0293	0.0152	0.0401	0.3572
10	0.1375	0.0607	0.0284	0.0231	0.0164	0.0092	0.0044	0.0053	0.2848
20	0.1089	0.0588	0.0180	0.0143	0.0127	0.0092	0.0021	0.0009	0.2249
30	0.0473	0.0231	0.0090	0.0048	0.0028	0.0007	0.0007	0.0005	0.0888
40	0.0178	0.0051	0.0021	0.0016	0.0014	0.0002	0.0002	0.0002	0.0286
50	0.0067	0.0007	0.0002	0.0005	0.0009	0.0005	0.	0.	0.0095
60	0.0016	0.0012	0.	0.0002	0.	0.	0.	0.	0.0030
70	0.0014	0.0009	0.0005	0.	0.	0.	0.	0.	0.0028
80	0.0005	0.	0.	0.	0.	0.	0.	0.	0.0005
90	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	257	133	47	30	32	24	8	7	538	2.23	1.68
30	295	117	41	40	27	24	18	14	576	2.31	1.88
60	142	63	20	8	9	11	0	1	254	1.89	1.38
90	118	62	20	10	10	5	3	1	229	1.97	1.42
120	91	53	22	13	3	3	0	1	186	1.91	1.22
150	72	34	13	5	9	8	0	0	141	2.07	1.50
180	64	39	13	10	11	5	1	2	145	2.27	1.63
210	49	16	16	2	1	0	0	0	84	1.69	0.94
240	53	30	7	3	5	2	1	0	101	1.88	1.31
270	34	14	17	23	16	0	0	2	106	2.84	1.65
300	32	14	1	1	1	1	0	0	50	1.56	1.03
330	29	13	4	8	11	2	0	0	67	2.48	1.65
360	31	4	4	5	1	0	0	0	45	1.69	1.16
390	9	4	1	0	0	0	0	0	14	1.43	0.65
420	16	5	0	0	0	0	0	0	21	1.24	0.44
450	6	6	0	0	2	0	0	0	14	2.00	1.36
480	12	3	2	4	0	0	0	1	22	2.18	1.76
510	3	0	3	1	1	0	0	0	8	2.62	1.51
540	6	1	0	0	0	0	0	0	7	1.14	0.38
570	2	0	0	0	0	0	0	0	2	1.00	0.
600	0	0	0	0	0	0	0	0	0	0.	0.
630	3	5	0	0	0	0	0	0	8	1.62	0.52
660	4	0	0	0	0	0	0	0	4	1.00	0.
690	0	0	0	0	0	1	0	0	1	6.00	0.
720	1	0	0	0	0	3	0	0	4	4.75	2.50
750	2	0	0	0	0	0	0	0	2	1.00	0.
780	0	0	0	0	0	1	0	0	1	6.00	0.
810	2	0	0	0	0	0	0	0	2	1.00	0.
840	0	0	0	0	0	0	0	0	0	0.	0.
870	0	0	0	0	0	0	0	0	0	0.	0.
900	0	0	0	0	0	0	0	0	0	0.	0.
930	0	0	0	0	0	0	0	0	0	0.	0.
960	0	0	0	0	0	0	0	0	0	0.	0.
990	6	5	0	0	0	1	0	0	12	1.83	1.40
1020	0	0	0	0	0	0	0	0	0	0.	0.
1050	0	0	0	0	0	0	0	0	0	0.	0.
1080	0	0	0	0	0	0	0	0	0	0.	0.
1110	0	0	0	0	0	0	0	0	0	0.	0.
1140	0	0	0	0	0	0	0	0	0	0.	0.
1170	0	0	0	1	0	0	0	0	1	4.00	0.
TOTAL	1339	621	231	164	139	91	31	29			
AVE	136.48	131.04	130.71	151.46	139.96	128.74	54.68	86.38	134.04		
S D	198.62	193.23	173.71	215.58	187.92	232.39	76.22	139.91	195.36		

FRACTION OF SHELTERS PER PF CATEGORY

CONTAM. PLANE WIDTH	1	2	3	4	5	6	7	8	TOTAL
0	0.0972	0.0503	0.0178	0.0113	0.0121	0.0091	0.0030	0.0026	0.2034
30	0.1115	0.0442	0.0155	0.0151	0.0102	0.0091	0.0068	0.0053	0.2178
60	0.0537	0.0238	0.0076	0.0030	0.0034	0.0042	0.	0.0004	0.0960
90	0.0446	0.0234	0.0076	0.0038	0.0038	0.0019	0.0011	0.0004	0.0866
120	0.0344	0.0200	0.0083	0.0049	0.0011	0.0011	0.	0.0004	0.0703
150	0.0272	0.0129	0.0049	0.0019	0.0034	0.0030	0.	0.	0.0533
180	0.0242	0.0147	0.0049	0.0038	0.0042	0.0019	0.0004	0.0008	0.0548
210	0.0185	0.0060	0.0060	0.0008	0.0004	0.	0.	0.	0.0318
240	0.0200	0.0113	0.0026	0.0011	0.0019	0.0008	0.0004	0.	0.0382
270	0.0129	0.0053	0.0064	0.0087	0.0060	0.	0.	0.0008	0.0401
300	0.0121	0.0053	0.0004	0.0004	0.0004	0.0004	0.	0.	0.0189
330	0.0110	0.0049	0.0015	0.0030	0.0042	0.0008	0.	0.	0.0253
360	0.0117	0.0015	0.0015	0.0019	0.0004	0.	0.	0.	0.0170
390	0.0034	0.0015	0.0004	0.	0.	0.	0.	0.	0.0053
420	0.0060	0.0019	0.	0.	0.	0.	0.	0.	0.0079
450	0.0023	0.0023	0.	0.	0.0008	0.	0.	0.	0.0053
480	0.0045	0.0011	0.0008	0.0015	0.	0.	0.	0.0004	0.0083
510	0.0011	0.	0.0011	0.0004	0.0004	0.	0.	0.	0.0030
540	0.0023	0.0004	0.	0.	0.	0.	0.	0.	0.0026
570	0.0008	0.	0.	0.	0.	0.	0.	0.	0.0008
600	0.	0.	0.	0.	0.	0.	0.	0.	0.
630	0.0011	0.0019	0.	0.	0.	0.	0.	0.	0.0030
660	0.0015	0.	0.	0.	0.	0.	0.	0.	0.0015
690	0.	0.	0.	0.	0.	0.0004	0.	0.	0.0004
720	0.0004	0.	0.	0.	0.	0.0011	0.	0.	0.0015
750	0.0008	0.	0.	0.	0.	0.	0.	0.	0.0008
780	0.	0.	0.	0.	0.	0.0004	0.	0.	0.0004
810	0.0008	0.	0.	0.	0.	0.	0.	0.	0.0008
840	0.	0.	0.	0.	0.	0.	0.	0.	0.
870	0.	0.	0.	0.	0.	0.	0.	0.	0.
900	0.	0.	0.	0.	0.	0.	0.	0.	0.
930	0.	0.	0.	0.	0.	0.	0.	0.	0.
960	0.	0.	0.	0.	0.	0.	0.	0.	0.
990	0.0023	0.0019	0.	0.	0.	0.0004	0.	0.	0.0045
1020	0.	0.	0.	0.	0.	0.	0.	0.	0.
1050	0.	0.	0.	0.	0.	0.	0.	0.	0.
1080	0.	0.	0.	0.	0.	0.	0.	0.	0.
1110	0.	0.	0.	0.	0.	0.	0.	0.	0.
1140	0.	0.	0.	0.	0.	0.	0.	0.	0.
1170	0.	0.	0.	0.0004	0.	0.	0.	0.	0.0004
TOTAL	0.5062	0.2348	0.0873	0.0620	0.0526	0.0344	0.0117	0.0110	

NUMBER OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	114	58	18	20	22	12	8	8	260	2.56	1.97
3	1537	807	295	227	176	136	66	131	3375	2.41	1.91
4	176	127	87	75	79	65	24	64	697	3.52	2.27
5	3	0	0	0	0	0	0	1	4	2.75	3.50
6	0	0	0	0	0	0	0	0	0	0.	0.
AVE	3.54	3.57	3.67	3.67	3.71	3.75	3.66	3.78	3.60		
S D	3.56	3.60	3.71	3.71	3.76	3.80	3.72	3.83	3.63		

FRACTION OF SHELTERS PER PF CATEGORY

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL
2	0.0263	0.0134	0.0042	0.0046	0.0051	0.0028	0.0018	0.0018	0.0600
3	0.3545	0.1861	0.0680	0.0524	0.0406	0.0314	0.0152	0.0302	0.7784
4	0.0406	0.0293	0.0201	0.0173	0.0182	0.0150	0.0055	0.0148	0.1607
5	0.0007	0.	0.	0.	0.	0.	0.	0.0002	0.0009
6	0.	0.	0.	0.	0.	0.	0.	0.	0.

SHELTERS WITH INTERIOR PARTITIONS

NUMBER OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
266	159	74	69	65	46	25	34	738	2.89	2.09

FRACTION OF SHELTERS PER PF CATEGORY

1	2	3	4	5	6	7	8	TOTAL
0.0613	0.0367	0.0171	0.0159	0.0150	0.0106	0.0058	0.0078	0.1702

NUMBER OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	0	0	0	0	0	0	0	0	0.	0.
25	5	0	0	C	0	0	0	0	5	1.00	0.
50	43	16	2	4	3	2	1	0	71	1.85	1.43
75	179	84	20	13	14	6	2	1	319	1.84	1.32
100	657	283	119	88	62	35	20	24	1288	2.16	1.67
125	221	157	66	46	46	42	14	20	612	2.71	1.95
150	333	189	75	6C	57	43	20	35	812	2.63	2.01
175	132	58	23	22	13	15	13	15	291	2.65	2.15
200	106	90	38	33	23	19	5	35	349	3.08	2.25
225	49	44	13	18	20	9	5	3	161	2.86	1.89
250	36	25	13	7	7	10	2	12	112	3.20	2.37
275	14	15	14	12	12	3	5	7	82	3.70	2.15
300	17	10	7	7	9	12	3	15	80	4.30	2.56
325	12	8	2	5	6	1	2	3	39	3.28	2.28
350	9	3	3	C	0	2	0	4	21	3.24	2.79
375	2	1	0	1	0	1	1	4	10	5.30	3.02
400	3	C	0	1	2	2	2	5	15	5.53	2.67
425	2	1	1	C	1	3	0	4	12	5.17	2.76
450	2	1	1	2	0	2	0	5	13	5.15	2.79
475	8	7	3	3	2	6	3	12	44	4.68	2.76
AVE	147.36	156.68	164.37	171.20	174.77	192.55	189.80	235.42	161.91		
S D	159.27	168.97	177.92	186.38	189.83	214.16	210.67	260.41	177.26		

FRACTION OF SHELTERS PER PF CATEGORY

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.0012	0.	0.	0.	0.	0.	0.	0.	0.0012
50	0.0099	0.0037	0.0005	0.0009	0.0007	0.0005	0.0002	0.	0.0164
75	0.0413	0.0194	0.0046	0.0030	0.0032	0.0014	0.0005	0.0002	0.0736
100	0.1515	0.0653	0.0274	0.0203	0.0143	0.0081	0.0046	0.0055	0.2970
125	0.0510	0.0362	0.0152	0.0106	0.0106	0.0097	0.0032	0.0046	0.1411
150	0.0768	0.0436	0.0173	0.0138	0.0131	0.0099	0.0046	0.0081	0.1873
175	0.0304	0.0134	0.0053	0.0051	0.0030	0.0035	0.0030	0.0035	0.0671
200	0.0244	0.0208	0.0088	0.0076	0.0053	0.0044	0.0012	0.0081	0.0805
225	0.0113	0.0101	0.0030	0.0042	0.0046	0.0021	0.0012	0.0007	0.0371
250	0.0083	0.0058	0.0030	0.0016	0.0016	0.0023	0.0005	0.0028	0.0258
275	0.0032	0.0035	0.0032	0.0028	0.0028	0.0007	0.0012	0.0016	0.0189
300	0.0039	0.0023	0.0016	0.0016	0.0021	0.0028	0.0007	0.0035	0.0185
325	0.0028	0.0018	0.0005	0.0012	0.0014	0.0002	0.0005	0.0007	0.0090
350	0.0021	0.0007	0.0007	0.	0.	0.0005	0.	0.0009	0.0048
375	0.0005	0.0002	0.	0.0002	0.	0.0002	0.0002	0.0009	0.0023
400	0.0007	0.	0.	0.0002	0.0005	0.0005	0.0005	0.0012	0.0035
425	0.0005	0.0002	0.0002	0.	0.0002	0.0007	0.	0.0009	0.0028
450	0.0005	0.0002	0.0002	0.0005	0.	0.0005	0.	0.0012	0.0030
475	0.0018	0.0016	0.0007	0.0007	0.0005	0.0014	0.0007	0.0028	0.0101

DOSE SOURCE

I=1 NC SINGLE CONTRIBUTION 40 PERCENT OR GREATER
I=2 ONE WALL CONTRIBUTES 40 PERCENT OR GREATER
I=3 TWO WALLS CONTRIBUTE 4C PERCENT OR GREATER EACH
I=4 CEILING CONTRIBUTES 40 PERCENT OR GREATER
I=5 CEILING AND ONE WALL CONTRIBUTE 40 PFRCENT OR GREATER EACH

NUMBER OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	268	135	40	40	14	12	4	163	676	3.39	2.84
2	591	382	171	147	116	87	32	12	1538	2.52	1.73
3	45	36	16	7	37	17	7	0	165	3.21	1.96
4	883	417	158	121	102	89	42	29	1841	2.31	1.77
5	43	22	15	7	8	8	13	0	116	2.92	2.11
AVE	2.91	2.81	2.84	2.71	2.91	2.97	3.29	1.49	2.81		
S D	3.16	3.05	3.07	2.95	3.09	3.17	3.51	1.82	3.06		

FRACTICN OF SHELTERS PER PF CATEGORY

I	1	2	3	4	5	6	7	8	TOTAL
1	C.0618	0.0311	0.0092	0.C092	0.0032	0.`028	C.0009	0.0376	0.1559
2	0.1363	0.0881	0.0394	0.C339	0.C268	0.0201	0.0074	0.C028	0.3547
3	0.0104	0.0083	0.0037	0.CC16	0.0085	0.0039	C.0016	0.	0.0381
4	C.2036	0.0962	C.C364	0.C279	0.C235	0.02C5	C.0097	0.0067	0.4246
5	0.0099	0.0051	0.0035	0.CC16	C.C018	0.0C18	0.0030	0.	0.0268

X. BUILDING STATISTICS

The 1541 sample buildings are rated by PF according to their PF class. Definitions of category headings such as Contaminated Plane Width and Log Floor Area are found in Section IV. B. 2. of Chapter 3.

NUMBER OF BUILDINGS PER PF CLASS

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	1	2	0	0	0	3	1	4	11	5.64	2.69
1	61	62	19	14	10	15	3	4	188	2.61	1.81
2	168	76	29	35	29	25	14	20	396	2.78	2.15
3	159	118	42	28	19	29	17	30	442	2.85	2.20
4	55	48	29	34	22	9	5	13	215	3.15	2.02
5	20	26	13	16	15	8	3	12	113	3.67	2.22
6	12	19	14	10	7	11	9	8	90	4.00	2.27
7	6	7	2	3	4	1	1	6	30	3.97	2.61
8	0	1	2	0	1	2	1	6	13	6.15	2.23
9	1	1	0	0	0	0	0	5	7	6.14	3.18
10	0	0	0	0	1	1	0	4	6	7.17	1.33
11	0	0	0	1	0	0	0	1	2	6.00	2.83
12	0	0	0	0	0	0	0	4	4	8.00	0.
13	0	0	0	1	1	0	0	5	7	7.00	1.73
14	0	0	0	0	1	0	0	2	3	7.00	1.73
15	0	0	0	0	0	0	0	1	1	8.00	0.
16	0	1	0	0	0	0	2	2	5	6.40	2.51
17	0	0	0	0	0	0	0	1	1	8.00	0.
18	0	0	0	0	0	0	0	0	0	0.	0.
19	0	0	0	0	0	0	0	0	0	0.	0.
20	0	0	0	0	0	0	0	0	0	0.	0.
21	0	0	0	0	0	0	1	0	1	7.00	0.
22	0	0	0	0	0	0	0	3	3	8.00	0.
23	0	0	0	0	0	0	0	0	0	0.	0.
24	0	0	0	0	0	0	0	0	0	0.	0.
25	0	0	0	0	0	0	0	0	0	0.	0.
26	0	0	0	0	0	0	0	0	0	0.	0.
27	0	0	0	0	0	0	0	0	0	0.	0.
28	0	0	0	0	0	0	0	0	0	0.	0.
29	0	0	0	0	0	0	0	0	0	0.	0.
30	0	0	0	0	0	0	0	0	0	0.	0.
31	0	0	0	0	0	0	0	0	0	0.	0.
32	0	0	0	0	0	0	0	0	0	0.	0.
33	0	0	0	0	0	0	0	0	0	0.	0.
34	0	0	0	0	0	0	0	0	0	0.	0.
35	0	0	0	0	0	0	0	0	0	0.	0.
36	0	0	0	0	0	0	0	0	0	0.	0.
37	0	0	0	0	0	0	0	1	1	8.00	0.
38	0	0	0	0	0	0	0	0	0	0.	0.
39	0	0	0	0	0	0	0	0	0	0.	0.
40	0	0	0	0	0	0	0	0	0	0.	0.
41	0	0	0	0	0	0	0	0	0	0.	0.
42	0	0	0	0	0	0	0	0	0	0.	0.
43	0	0	0	0	0	0	0	0	0	0.	0.
44	0	0	0	0	0	0	0	0	0	0.	0.
AVE	2.73	3.01	3.32	3.44	3.66	3.14	4.19	6.00	3.35		
S D	3.0[illegible]	3.45	3.69	3.90	4.28	3.68	5.60	8.11	4.16		

FRACTION OF BUILDINGS PER PF CLASS

STORY NUMBER	1	2	3	4	5	6	7	8	TOTAL
0	0.0006	0.0013	0.	0.	0.	0.0019	0.0006	0.0026	0.0071
1	0.0396	0.0403	0.0123	0.0091	0.0065	0.0097	0.0019	0.0026	0.1222
2	0.1092	0.0494	0.0188	0.0227	0.0188	0.0162	0.0091	0.0130	0.2573
3	0.1033	0.0767	0.0273	0.0182	0.0123	0.0188	0.0110	0.0195	0.2872
4	0.0357	0.0312	0.0188	0.0221	0.0143	0.0058	0.0032	0.0084	0.1397
5	0.0130	0.0169	0.0084	0.0104	0.0097	0.0052	0.0019	0.0078	0.0734
6	0.0078	0.0123	0.0091	0.0065	0.0045	0.0071	0.0058	0.0052	0.0585
7	0.0039	0.0045	0.0013	0.0019	0.0026	0.0006	0.0006	0.0039	0.0195
8	0.	0.0006	0.0013	0.	0.0006	0.0013	0.0006	0.0039	0.0084
9	0.0006	0.0006	0.	0.	0.	0.	0.	0.0032	0.0045
10	0.	0.	0.	0.	0.0006	0.0006	0.	0.0026	0.0039
11	0.	0.	0.	0.0006	0.	0.	0.	0.0006	0.0013
12	0.	0.	0.	0.	0.	0.	0.	0.0026	0.0026
13	0.	0.	0.	0.0006	0.0006	0.	0.	0.0032	0.0045
14	0.	0.	0.	0.	0.0006	0.	0.	0.0013	0.0019
15	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0006
16	0.	0.0006	0.	0.	0.	0.	0.0013	0.0013	0.0032
17	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0006
18	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.0006	0.	0.0006
22	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.0019	0.0019
24	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0006
39	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF BUILDINGS PER PF CLASS

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	76	58	23	21	18	34	7	23	260	3.35	2.34
10	213	190	77	74	60	40	28	57	739	3.13	2.20
20	135	89	35	37	24	22	15	35	392	3.07	2.30
30	44	15	15	4	6	4	6	10	104	2.99	2.42
40	14	5	0	5	2	3	0	5	34	3.29	2.60
50	0	1	0	0	0	0	1	0	2	4.50	3.54
60	0	1	0	1	0	1	0	2	5	5.60	2.61
70	1	2	0	0	0	0	0	0	3	1.67	0.58
80	0	0	0	0	0	0	0	0	0	0.	0.
90	0	0	0	0	0	0	0	0	0	0.	0.
AVE	19.04	17.69	17.80	18.10	17.18	15.96	19.21	19.32	18.20		
S D	21.46	20.20	19.75	20.55	19.24	19.41	21.64	22.46	20.69		

FRACTION OF BUILDINGS PER PF CLASS

PERCENT APERTURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0494	0.0377	0.0149	0.C136	0.C117	0.0221	0.0045	0.0149	0.1689
10	0.1384	0.1235	C.C500	0.0481	0.0390	0.0260	0.0182	0.0370	0.4802
20	0.0877	0.0578	0.0227	0.0240	0.C156	0.0143	0.0097	0.0227	0.2547
30	0.0286	0.0097	0.0097	0.0026	0.0039	0.0026	C.0039	0.0065	0.0676
40	0.0C91	0.0032	0.	0.0032	0.0013	0.0019	0.	0.0032	0.0221
50	0.	0.0006	0.	0.	0.	0.	0.0C06	0.	0.0013
60	0.	0.0006	0.	0.0006	0.	C.0006	0.	0.0013	0.0032
70	0.0006	0.0013	0.	0.	0.	0.	0.	0.	0.0019
80	C.	0.	C.	0.	C.	0.	C.	0.	0.
90	0.	0.	0.	0.	0.	0.	C.	0.	0.

BUILDINGS WITH INTERIOR PARTITIONS

NUMBER OF BUILDINGS PER PF CLASS

1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
93	57	27	29	28	29	21	36	320	3.60	2.47

FRACTION OF BUILDINGS PER PF CLASS

1	2	3	4	5	6	7	8	TOTAL
0.0604	0.C370	0.C175	0.0188	0.C182	0.0188	0.0136	0.0234	0.2079

NUMBER OF BUILDINGS PER PF CLASS

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
2	32	39	10	13	12	8	1	2	117	2.76	1.76
3	413	276	113	107	71	65	33	68	1146	2.84	2.11
4	36	46	27	22	27	30	23	61	272	4.64	2.54
5	2	0	0	0	0	1	0	1	4	4.00	3.56
6	0	0	0	C	0	0	0	0	0	0.	0.
AVE	3.52	3.52	3.61	3.56	3.64	3.73	3.89	3.96	3.61		
S D	3.54	3.56	3.66	3.61	3.70	3.80	3.96	4.01	3.64		

FRACTION OF BUILDINGS PER PF CLASS

LOG FLOOR AREA	1	2	3	4	5	6	7	8	TOTAL
2	0.0208	0.0253	0.0065	0.0084	0.C078	0.0052	0.0006	0.0013	0.0760
3	0.2684	0.1793	0.0734	0.0695	0.C461	C.0422	0.0214	0.0442	0.7446
4	C.0234	0.0299	0.0175	C.0143	0.C175	0.0195	C.0149	0.0396	0.1767
5	0.0013	0.	0.	0.	0.	0.0036	C.	0.0006	0.0026
6	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF BUILDINGS PER PF CLASS

		2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	0	0	0	0	0	0	0	0	0	0.	0.
25	6	3	0	0	0	0	0	1	10	2.00	2.16
50	24	13	2	1	3	4	1	1	49	2.33	1.92
75	67	34	13	10	7	4	6	6	147	2.47	1.99
100	142	96	38	38	26	15	16	30	401	2.92	2.20
125	128	108	46	40	29	35	13	34	433	3.14	2.23
150	51	43	24	21	15	14	7	24	199	3.48	2.38
175	28	33	13	16	14	8	5	8	125	3.31	2.12
200	14	12	11	6	7	6	3	8	67	3.75	2.36
225	8	5	1	4	4	3	2	4	31	3.90	2.52
250	6	4	1	3	2	3	1	4	24	4.00	2.62
275	2	1	0	1	0	4	0	3	11	5.09	2.70
300	0	2	0	0	0	1	0	1	4	4.50	3.00
325	0	2	0	2	1	0	1	3	9	5.33	2.50
350	3	0	0	0	2	1	0	1	7	3.86	2.85
375	0	0	0	0	0	0	0	0	0	0.	0.
400	1	0	0	0	0	0	0	2	3	5.67	4.04
425	1	0	0	0	0	1	0	0	2	3.50	3.54
450	0	0	1	0	0	2	1	0	4	5.50	1.73
475	2	5	0	0	0	3	1	2	13	4.08	2.75
AVE	133.83	142.76	143.33	148.59	152.73	175.96	156.36	167.61	146.14		
S D	144.45	155.11	150.72	156.38	162.75	199.20	176.32	185.04	158.74		

FRACTION OF BUILDINGS PER PF CLASS

PSF	1	2	3	4	5	6	7	8	TOTAL
0	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.0039	0.0019	0.	0.	0.	0.	0.	0.0006	0.0065
50	0.0156	0.0084	0.0013	0.0006	0.0019	0.0026	0.0006	0.0006	0.0318
75	0.0435	0.0221	0.0084	0.0065	0.0045	0.0026	0.0039	0.0039	0.0955
100	0.0923	0.0624	0.0247	0.0247	0.0169	0.0097	0.0104	0.0195	0.2606
125	0.0832	0.0702	0.0299	0.0260	0.0188	0.0227	0.0084	0.0221	0.2814
150	0.0331	0.0279	0.0156	0.0136	0.0097	0.0091	0.0045	0.0156	0.1293
175	0.0182	0.0214	0.0034	0.0104	0.0091	0.0052	0.0032	0.0052	0.0812
200	0.0091	0.0078	0.0071	0.0039	0.0045	0.0039	0.0019	0.0052	0.0435
225	0.0052	0.0032	0.0006	0.0026	0.0026	0.0019	0.0013	0.0026	0.0201
250	0.0039	0.0026	0.0006	0.0019	0.0013	0.0019	0.0006	0.0026	0.0156
275	0.0013	0.0006	0.	0.0006	0.	0.0026	0.	0.0019	0.0071
300	0.	0.0013	0.	0.	0.	0.0006	0.	0.0006	0.0026
325	0.	0.0013	0.	0.0013	0.0006	0.	0.0006	0.0019	0.0058
350	0.0019	0.	0.	0.	0.0013	0.0006	0.	0.0006	0.0045
375	0.	0.	0.	0.	0.	0.	0.	0.	0.
400	0.0006	0.	0.	0.	0.	0.	0.	0.0013	0.0019
425	0.0006	0.	0.	0.	0.	0.0006	0.	0.	0.0013
450	0.	0.	0.0006	0.	0.	0.0013	0.0006	0.	0.0026
475	0.0013	0.0032	0.	0.	0.	0.0019	0.0006	0.0013	0.0084

NUMBER OF BUILDINGS PER PF CLASS

PV	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
11	C	C	0	C	C	1	0	0	1	6.00	0.
21	.	2	2	C	C	0	0	C	9	1.67	0.87
22	11	2	1	C	0	C	0	0	14	1.29	0.61
31	3	3	0	C	0	0	0	C	6	1.50	0.55
32	41	29	13	9	4	9	1	3	109	2.56	1.85
34	27	8	4	3	4	C	0	1	47	2.02	1.58
35	111	49	12	19	11	14	5	7	228	2.42	1.95
36	193	176	77	68	49	26	12	20	621	2.73	1.84
37	14	17	10	1C	7	7	6	2	73	3.47	2.06
39	3	2	1	1	0	0	1	2	1C	3.70	2.91
41	5	5	1	3	5	0	0	1	20	3.15	1.95
42	0	1	2	C	C	1	0	0	4	3.50	1.73
43	20	9	7	6	12	12	10	37	113	5.14	2.7C
44	1	C	1	C	3	0	C	5	10	5.90	2.51
45	0	1	0	C	0	C	C	0	1	2.CC	0.
46	0	1	0	0	C	0	0	0	1	2.00	0.
47	0	C	0	C	C	0	0	1	1	8.00	0.
48	0	C	0	0	0	0	0	0	0	0.	0.
49	1	0	0	C	C	0	C	C	1	1.C0	0.
51	9	8	0	3	1	0	2	0	23	2.43	1.85
52	3	3	2	0	1	2	1	1	13	3.62	2.47
53	0	C	0	1	0	0	0	0	1	4.00	0.
54	0	C	0	C	C	C	0	0	0	0.	0.
55	C	C	0	0	C	C	0	0	0	0.	0.
56	0	C	0	0	0	0	0	0	0	0.	0.
57	23	27	11	14	10	21	15	39	160	4.74	2.62
58	4	4	2	3	2	1	1	7	24	4.54	2.75
59	2	1	2	C	1	3	1	1	11	4.36	2.46
91	0	C	0	0	0	0	0	0	0	0.	0.
61	1	1	0	0	0	0	1	0	3	3.33	3.21
62	1	C	0	C	C	C	0	C	1	1.00	0.
71	3	11	1	2	C	7	1	5	30	4.17	2.55
81	0	C	0	0	0	0	0	0	0	0.	0.
AVE	9.13	10.52	10.04	1C.86	11.02	14.48	15.75	17.11	11.13		
S D	10.76	12.66	11.89	12.85	12.69	17.25	17.99	19.C5	13.29		

FRACTION OF BUILDINGS PER PF CLASS

PV	1	2	3	4	5	6	7	8	TOTAL
11	0.	0.	0.	0.	0.	0.0006	0.	0.	0.0006
21	0.0032	0.0013	0.0013	0.	0.	0.	0.	0.	0.0058
22	0.0071	0.0013	0.0006	0.	0.	0.	0.	0.	0.0091
31	0.0019	0.0019	0.	0.	0.	0.	0.	0.	0.0039
32	0.0266	0.0198	0.0084	0.0058	0.0026	0.0058	0.0006	0.0019	0.0708
34	0.0175	0.0052	0.0026	0.0019	0.0026	0.	0.	0.0006	0.0305
35	0.0721	0.0318	0.0078	0.0123	0.0071	0.0091	0.0032	0.0045	0.1481
36	0.1254	0.1144	0.0500	0.0442	0.0318	0.0169	0.0078	0.0130	0.4035
37	0.0091	0.0110	0.0065	0.0065	0.0045	0.0045	0.0039	0.0013	0.0474
38	0.0019	0.0013	0.0006	0.0006	0.	0.	0.0006	0.0013	0.0065
41	0.0032	0.0032	0.0006	0.0019	0.0032	0.	0.	0.0006	0.0130
42	0.	0.0006	0.0013	0.	0.	0.0006	0.	0.	0.0026
43	0.0130	0.0058	0.0045	0.0039	0.0078	0.0078	0.0065	0.0240	0.0734
44	0.0006	0.	0.0006	0.	0.0019	0.	0.	0.0032	0.0065
45	0.	0.0006	0.	0.	0.	0.	0.	0.	0.0006
46	0.	0.0006	0.	0.	0.	0.	0.	0.	0.0006
47	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0006
48	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.0006	0.	0.	0.	0.	0.	0.	0.	0.0006
51	0.0058	0.0052	0.	0.0019	0.0006	0.	0.0013	0.	0.0149
52	0.0019	0.0019	0.0013	0.	0.0006	0.0013	0.0006	0.0006	0.0084
53	0.	0.	0.	0.0006	0.	0.	0.	0.	0.0006
54	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	0.0149	0.0175	0.0071	0.0091	0.0065	0.0136	0.0097	0.0253	0.1040
58	0.0026	0.0026	0.0013	0.0019	0.0013	0.0006	0.0006	0.0045	0.0156
59	0.0013	0.0006	0.0013	0.	0.0006	0.0019	0.0006	0.0006	0.0071
91	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	0.0006	0.0006	0.	0.	0.	0.	0.0006	0.	0.0019
62	0.0006	0.	0.	0.	0.	0.	0.	0.	0.0006
71	0.0019	0.0071	0.0006	0.0013	0.	0.0045	0.0006	0.0032	0.0195
81	0.	0.	0.	0.	0.	0.	0.	0.	0.

NUMBER OF BASEMENTS PER PF CLASS

PERCENT EXPOSURE	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
0	147	145	61	53	52	61	37	138	700	4.06	2.62
10	72	43	28	19	17	21	11	15	226	3.21	2.26
20	72	47	27	35	28	14	10	6	239	3.05	1.96
30	79	61	21	12	13	10	6	9	211	2.61	1.98
40	40	27	15	22	12	8	1	5	130	2.94	1.91
50	55	28	9	4	11	5	1	1	114	2.[illegible]	1.67
60	18	11	5	5	3	1	1	0	44	2.34	1.57
70	5	7	1	0	2	2	0	1	18	2.89	2.14
80	3	2	1	2	0	0	0	0	8	2.25	1.28
90	0	0	1	C	0	0	0	C	1	3.00	0.
TOTAL	491	371	169	158	138	122	67	175			
AVE	26.49	23.84	22.99	22.66	22.90	17.79	14.55	9.91	22.09		
S D	33.04	31.07	29.98	29.27	29.60	24.74	19.95	15.23	29.17		

TOTAL NUMBER OF SUBBASEMENTS IS 34

FRACTION OF BASEMENTS PER PF CLASS

PERCENT EXPOSURE	1	2	3	4	5	6	7	8	TOTAL
0	0.0869	0.0857	0.0361	0.0349	0.0308	0.0361	0.0219	0.0816	0.4140
10	0.0426	0.0254	0.0166	0.0112	0.0101	0.0124	0.0065	0.0089	0.1336
20	0.0426	0.0278	0.0160	0.0207	0.0166	0.0083	0.0059	0.0035	0.1413
30	0.0467	0.0361	0.0124	0.0071	0.0077	0.0059	0.0035	0.0053	0.1248
40	0.0237	0.0160	0.0089	0.0130	0.0071	0.0047	0.0006	0.0030	0.0769
50	0.0325	0.0166	0.0053	0.0024	0.0065	0.0030	0.0006	0.0006	0.0674
60	0.0106	0.0065	0.0030	0.0030	0.0018	0.0006	0.0006	0.	0.0260
70	0.0030	0.0041	0.0006	0.	0.0012	0.0012	0.	0.0006	0.0106
80	0.0018	0.0012	0.0006	0.0012	0.	0.	0.	0.	0.0047
90	0.	0.	0.0006	0.	0.	0.	0.	0.	0.0006
TOTAL	0.2904	0.2194	0.0999	0.0934	0.0816	0.0721	0.0396	0.1035	

NUMBER OF BUILDINGS PER PF CLASS

BUILDING PARTS	1	2	3	4	5	6	7	8	TOTAL	AV PF	S D
1	430	299	119	116	78	74	36	76	1228	2.89	2.13
2	39	39	24	17	21	16	10	27	193	3.85	2.43
3	12	14	4	6	4	8	4	13	65	4.25	2.63
4	2	4	1	1	4	2	2	7	23	5.17	2.57
5	0	2	2	1	1	3	2	5	16	5.69	2.24
6	0	2	0	1	1	0	2	1	7	5.00	2.45
7	0	0	0	0	1	0	0	1	2	6.50	2.12
8	0	0	0	0	0	0	0	1	1	8.00	0.
9	0	1	0	0	0	0	0	0	1	2.00	0.
10	0	0	0	0	0	0	1	0	1	7.00	0.
11	0	0	0	0	0	0	0	1	1	8.00	0.
12	0	0	0	0	0	0	0	0	0	0.	0.
13	0	0	0	0	0	0	0	0	0	0.	0.
14	0	0	0	0	0	1	0	0	1	6.00	0.
15	0	0	0	0	0	0	0	0	0	0.	0.
16	0	0	0	0	0	0	0	0	0	0.	0.
17	0	0	0	0	0	0	0	0	0	0.	0.
18	0	0	0	0	0	0	0	0	0	0.	0.
19	0	0	0	0	0	0	0	0	0	0.	0.
20	0	0	0	0	0	0	0	0	0	0.	0.
TOTAL	483	361	150	142	110	104	57	132			
AVE	1.14	1.29	1.29	1.29	1.51	1.61	1.89	1.92	1.36		
S D	1.23	1.53	1.46	1.49	1.85	2.23	2.56	2.48	1.67		

FRACTION OF BUILDINGS PER PF CLASS

BUILDING PARTS	1	2	3	4	5	6	7	8	TOTAL
1	0.2794	0.1943	0.0773	0.0754	0.0507	0.0481	0.0234	0.0494	0.7979
2	0.0253	0.0253	0.0156	0.011C	0.0136	0.0104	0.0065	0.0175	0.1254
3	0.0078	0.0091	C.0026	0.0C39	0.0026	0.0052	C.0026	0.0084	0.0422
4	0.0013	0.0026	0.C006	0.0C06	0.C026	0.0013	C.0013	0.0045	0.0149
5	C.	0.0013	0.0013	0.0006	0.0006	0.0019	0.0013	0.0032	0.0104
6	0.	0.0013	0.	C.CC06	C.0006	0.	0.0013	0.0006	0.0045
7	0.	0.	0.	0.	0.C006	0.	0.	0.0006	0.0013
8	0.	0.	0.	0.	0.	0.	0.	0.0006	0.0006
9	0.	0.0006	0.	0.	0.	0.	G.	0.	0.0006
10	0.	0.	G.	0.	0.	0.	C.0006	0.	0.0006
11	0.	0.	0.	0.	0.	C.	C.	0.0006	0.0006
12	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	C.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.00C6	0.	0.	0.0006
15	0.	0.	0.	0.	0.	0.	C.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	C.	0.	0.	C.	0.	0.	C.
19	0.	0.	0.	0.	0.	0.	C.	0.	0.
20	C.	0.	0.	0.	0.	0.	C.	0.	0.
TOTAL	0.3138	0.2346	0.0975	0.C923	0.C715	C.0676	0.0370	0.0858	

Appendix F

Application of Statistical Sampling Procedures to Estimate Probable Error of NFSS Findings

This Appendix was originally submitted to OCD as Research Memorandum RM 81-4*, except for minor editorial changes.

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* W. K. Grogan, E. L. Hill, and D. T. Searls. Application of Statistical Sampling Procedures to Estimate Probable Error of NFSS Findings. Research Memorandum RM 81-4. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 19 November 1962.

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Appendix F

Application of Statistical Sampling Procedures to Estimate Probable Error of NFSS Findings

I. INTRODUCTION

The Research Triangle Institute estimated the probable error of the NFSS findings by surveying a statistical sample of 33 buildings. The procedures used, findings, and an analysis of findings of the survey are reported in Part I, Chapter 4. This appendix gives the details of the selection of sample buildings surveyed by RTI.

II. DESCRIPTION OF THE SAMPLE

A. Size of Sample

The time element involved in conducting the field work and data analysis necessarily restricted the size of the sample. It was estimated that this time factor would make it possible to survey no more than 60 buildings.

An analysis was made of the significance with which the differences between the NBS-NFSS Computer Program and the Engineering Manual could be estimated. Based on the results of this analysis, as presented in Section III, a sample of 30 buildings was considered adequate for detecting differences in estimated PF ratings of 10 units.

The size of the sample was set at 33 buildings by a systematic subsample of every other building in an initial sample of 60 with a random starting point chosen in each region. Buildings from regions with only one sample building initially were included automatically in the subsample.

B. Selection of Sample Buildings

1. Development of a Sampling Unit--the Cluster

The universe to be sampled consisted of all buildings in the largest forty cities which had one or more shelters rated in PF Categories 2, 3

or 4 in Phase 1 of the NFSS. Table F-I lists the cities comprising the universe and indicates, by county, the standard locations falling within the boundaries of each city. A complete listing of all buildings for which Phase 1 FOSDIC Forms were submitted is on magnetic tape at the National Bureau of Standards. Unfortunately, data were not available on the total number of buildings in the restricted universe having at least one shelter falling in the selected PF categories. In order to obtain a probability sample of these buildings, it was necessary to employ an indirect procedure which utilized shelter information that was available.

Summaries by standard location of the number of shelters in PF Categories 2, 3, and 4 were the data used. Each city was assigned a number of clusters of shelters by dividing the total number of shelters in Categories 2-4 by the average number of shelters per building for the county in which the city appeared. Counties were the smallest political subdivisions on which data were available in summary form on the total number of shelters in all PF categories. (Table F-II, Column 2, gives the number of clusters determined in each region.)

2. Construction of Strata

Equal sized strata in terms of numbers of clusters were then constructed within an OCD region. OCD Regions 4 and 6 were combined for simplification. The number of strata constructed in a region was approximately proportional to the number of clusters it contained. OCD Regions 3, 5, and 8 were each assigned one stratum. (Table F-II, Column 3 for the number of strata assigned to each region.)

TABLE F-I

Cities Comprising the Restricted Universe

OCD Region	City	County	Standard Location Nos.	No. of Standard Locations in City
1	New York City, N. Y.	Queens	16450001-0680	2225
		Manhattan	16440001-0275	
		Richmond	16460001-0085	
		Brooklyn	16420001-0811	
		Bronx	16410001-0374	
	Boston, Mass.	Suffolk	13150001-0156	156
	Buffalo, N. Y.	Erie	16310001-0072	72
	Newark, N. J.	Essex	15410036-0135	100
	Rochester, N. Y.	Monroe	16510001-0090	90
2	Washington, D. C.1/		22110001-0125	125
	Cleveland, Ohio	Cuyahoga	25410001-0205	205
	Pittsburgh, Pa.	Alleghany	26810017-0205	189
	Cincinnati, Ohio	Hamilton	25310001-0112	112
	Columbus, Ohio	Franklin	25510001-0097	97
	Louisville, Ky.	Jefferson	23510001-0112	112
	Toledo, Ohio	Lucas	25D10001-0072	72
	Philadelphia, Pa.	Philadelphia	26750001-0370	370
	Baltimore, Md.1/		24130001-0168	168
3	Atlanta, Ga.	DeKalb	33230001-0009	9
		Fulton	33240001-0100	100
	Memphis, Tenn.	Shelby	37310001-0102	102
	Birmingham, Ala.	Jefferson	31110001-0061	61
4	Milwaukee, Wis.	Milwaukee	45510001-0186	186
	Minneapolis, Minn.	Hennepin	44330001-0127	127
	Indianapolis, Ind.	Marion	42410001-0146	146
	St. Paul, Minn.	Ramsey	44340001-0076	76
	Chicago, Ill.	Cook	41210011-0869	859
	Detroit, Mich.	Wayne	43330019-0452	434
5	Houston, Texas	Harris	55B10001-0121	121
	Dallas, Texas	Dallas	55720001-0174	174
	Ft. Worth, Texas	Tarrant	55920001-0080	80
	New Orleans, La.	Orleans	52420001-0155	155
	San Antonio, Texas	Bexar	55H10001-0092	92
	Oklahoma City, Okla.	Oklahoma	54230001-0091	91
6	Kansas City, Mo.	Clay	64110001-0009	9
		Jackson	64120014-0124	111
	Denver, Col.	Denver	61240001-0097	97
	St. Louis, Mo.1/		64340001-0128	128
7	Phoenix, Ariz.	Maricopa	71110001-0088	88
	Long Beach, Cal.	Los Angeles	72310079-0145	67
	Los Angeles, Cal.	Los Angeles	72310146-0777	632
	San Francisco, Cal.	San Francisco	72740001-0127	127
	Oakland, Cal.	Alameda	72710043-0141	99
	San Diego, Cal.	San Diego	72610001-0136	136
8	Seattle, Wash.	King	85210001-0118	118
	Portland, Ore.	Clackamas	84210001-0002	2
		Multnomah	84220001-0101	101

1/ Not part of a county.

TABLE F-II

Universe Characteristics

Region	Number of Universe Clusters	Number of Universe Strata	Number of Universe Clusters Per Stratum	Number Sample Clusters Sample of 60	Number Sample Clusters Sample of 33
1	27852	33	844	33	17
2	7425	9	825	9	5
3	655	1	655	1	1
4,6	10272	12	856	12	6
5	1091	1	1091	1	1
7	2151	3	717	3	2
8	838	1	838	1	1
TOTAL	50284	60		60	33

3. Cluster (sampling unit) Selection

One cluster (sampling unit) was selected for the sample from each stratum with equal probability of selection. This was achieved by drawing a random number between one and the total number of clusters in a stratum. For example, in Region 1 each stratum had 844 clusters (Table F-II). The chance of a cluster being selected for the sample in these strata was 1/844. By accumulating numbers of clusters by city in a region it was possible to determine the cities that contained sample clusters. Within a city, accumulations by standard location revealed the standard locations in which the sample clusters occurred. Table F-III shows the selected sampling units by standard location, city and region.

4. Determination of Sample Buildings

The next step was to determine the sample buildings in the selected standard locations. This was done by checking detailed IBM print-outs for these

TABLE F-III

Selected Sampling Units by Standard Location, City and Region

OCD Region	City	Sample Standard Location Number	Number of Sample Units Within S. L.	Sample Unit Selected	Cat.2,3, &4 Indicated Shelters in S.L.
1	Rochester	16510005	85	58	226
	Boston	13150026	62	30	236
	NYC				
	Queens	16450017	14	9	54
	"	16450538	5	4	20
	Manhattan	16440028	61	28	390
	"	16440063	14	14	84
	"	16440096	133	36	852
	"	16440126	29	17	190
	"	16440156	105	12	667
	"	16440204	55'	15	353
	"	16440260	11	11	68
	Brooklyn	16420207	10	10	51
	"	16420495	9	8	45
	Bronx	16410046	75	73	280
	"	16410138	57	43	211
	"	16410194	27	6	101
	Newark	15410066	30	14	124
2	Philadelphia	26750017	142	65	602
	D. C.	22110005	40	22	181
	"	22110062	72	56	332
	Cleveland	25410058	241	217	911
	Louisville	23510029	20	4	45
3	Memphis	37310043 37310044	6	6	22
5	Houston	55B10026	56	11	350
4,6	Indianapolis	42410013 42410014 42410015	1	1	3
	Chicago	41210065 41210066	1	1	3
	"	41210144	50	8	135
	"	41210490	325	197	889
	"	41210868 41210869	9	3	25
	St. Louis	64340122	114	84	510
7	Los Angeles	72310453	137	80	512
	San Francisco	72740072 72740073	9	4	42
8	Seattle	85210061	187	21	737

standard locations. From the print-outs the number of shelters in PF Categories 2-4 was accumulated. With this accumulation it was possible to determine the location of the sample cluster. The building containing the sample cluster was taken as the sample building. A knowledge of the number of shelters in PF Categories 2-4 contained in the building makes it possible to determine the probability of selection of any sample building. If a cluster contained more than one building, only one was selected for the sample with probability proportional to the number of shelters it contained in Categories 2-4. All clusters were delineated in such a manner that there was always an integral number of clusters per building or an integral number of buildings per cluster.

A knowledge of the probability of selection of each sample building is essential to insure correct estimate and variance computations. Variance computations were made in all cases using a collapsed stratum technique.

C. Example of Building Selection

The sample selection procedure will be illustrated in detail using data for Region 3. Data for the universe cities in Region 3 are presented in Table F-IV.

TABLE F-IV

Region 3 Data

Cities	Number of Shelters PF Cat. 2-4	Avg. No.: all Shelters Per Building	No. Clusters Assigned (1) ÷ (2)	Accumu-lated No. Clusters	Random Number Selected
	(1)	(2)	(3)	(4)	(5)
Atlanta	1104	4.5144	245	245	
Birmingham	539	3.0860	175	420	
Memphis	863	3.6771	235	655	626
	2506		655		

1. <u>Selection of Sample Cluster Within Stratum</u>

The 655 clusters in Region 3 composed one stratum. The random number selected between one and 655 was 626. As seen in Table F-IV, sample cluster 626 is located in Memphis. In fact, it will be number 206 of the 235 clusters in Memphis. Standard Location totals for Memphis are then accumulated as in Table F-V.

TABLE F-V

<u>Memphis Standard Location Totals</u>

Standard Location Number	No. Shelters Categories 2-4	Cumulative Shelters	Cumulative Clusters	Clusters Assigned
3731 0001	3	3	1	1
2	3	6	2	1
3	5	11	3	1
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
42	364	735	200	99
43	22			
44	0	757	206	6
45	2			
46	14	773	210	4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
99	4	861	234	1
100	0			
101	1			
102	1	863	235	1

Notice that standard locations with zero or few indicated shelters are combined with other standard locations.

2. <u>Delineation of Standard Location Containing Sample Cluster</u>

It can be seen from Table F-V that the grouping of Standard Locations 3731 0043--3731 0044 contains six clusters and the sample cluster number 206 will be the sixth cluster of the six.

Detailed IBM print-outs were obtained for the two standard locations. All buildings were listed with the number of shelters in Categories 2-4. Even though Standard Location 3731 0044 had zero indicated shelters, the print-out was checked to see if any changes had occurred since the summaries had been tabulated. In this case, no changes had occurred.

3. Delineation of Building to Be Surveyed

The total number of Category 2-4 shelters was 22. Since there were to be six clusters in the group of standard locations this meant an average of 3.667 shelters per cluster. Table F-VI presents the standard location information. Cluster numbers can be obtained by dividing the accumulated number of shelters for each building by the factor 3.667 and determining how many clusters have occurred to that point.

As seen in Table F-VI the sample building is the sixteenth building in Standard Location Number 43. In this case, the sample cluster coincided exactly with the sample building so that the probability of selection of the sample building is the same as the probability of selection of the sample cluster, e.g. 1/655.

Table F-VII presents the sample cities with the numbers of sample buildings per city. A listing of the sample buildings selected is in Table III of Part I, Chapter 4.

III. CONFIDENCE STATEMENT

Prior to receipt of survey findings, no clearcut conclusions could be drawn concerning confidence statements for differences that would result.

However, some general guidelines were constructed based upon certain assumptions as to the variability likely to be encountered in the data.

TABLE F-VI

Number of Shelters by Building in Memphis, Tenn., Sample Standard Locations

Standard Location Number	Building Number	No. of PF Category 2-4 Shelters	Cluster Numbers
43	1	1	
	2	6	
	3	1	1,2
	4	0	
	5	1	
	6	0	
	7	1	
	8	0	
	9	1	3
	10	1	
	11	1	
	12	2	4
	13	1	
	14	0	
	15	1	5
	16	5	6
	17	0	
	18	0	
44	19	0	
	20	0	

TABLE F-VII

Number of Sample Buildings Per Sample City

Region	Sample Cities	Number of Sample Buildings Sample of 60		Sample of 33	
1	Rochester	1		1	
	Boston	3		1	
	New York	28		14	
	Queens	3		2	
	Manhattan	14		7	
	Brooklyn	5		2	
	Bronx	6		3	
	Newark	1		1	
	TOTAL		33		17
2	Philadelphia	2		1	
	D. C.	3		2	
	Pittsburgh	1		--	
	Cleveland	1		1	
	Toledo	1		--	
	Louisville	1		1	
	TOTAL		9		5
3	Memphis	1	1	1	1
5	Houston	1	1	1	1
4,6	Indianapolis	1		1	
	Detroit	1		--	
	Chicago	7		4	
	Minneapolis	1		--	
	St. Louis	1		1	
	Kansas City	1		--	
	TOTAL		12		6
7	Los Angeles	1		1	
	San Francisco	2		1	
	TOTAL		3		2
8	Seattle	1	1	1	1
	GRAND TOTAL		60		33
	TOTAL CITIES		21		16

For example:

Let x_i = PF rating computed in Phase 1

Let y_i = PF rating computed in RTI survey using NBS Method

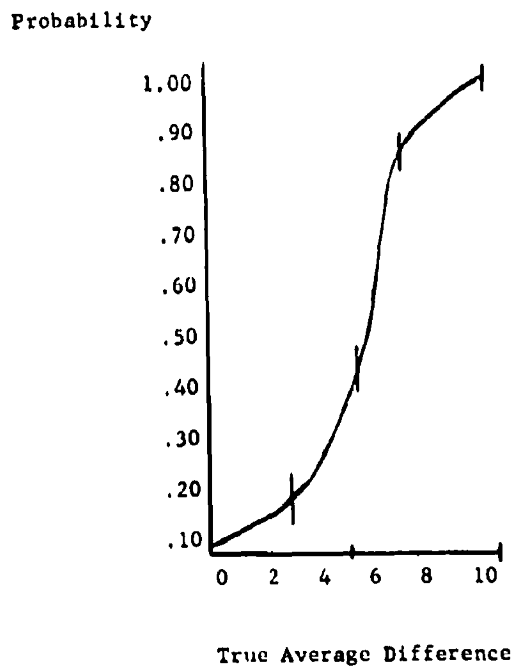
then $d_i = y_i - x_i$ is the difference observed.

An assumed standard deviation of differences of 15 units would imply that a range of ninety units would include virtually all differences observed if the survey were to include all buildings in the universe rather than a sample of them. Figure F-1 presents probabilities of detecting differences up to ten units for samples of size 33. If the true standard deviation is less than 15, the curve would be to the left of the one shown and if it is greater than 15 the curve would be to the right.

The graph indicates that a true average difference of five units would have a 50 percent chance of being detected while an average difference greater than ten units would almost certainly be detected.

FIGURE F-1

Probability of Detecting True Differences of 0 to 10 for Sample Size of 33 Under the Assumption That The Standard Deviation of Differences is 15



Appendix G

Sensitivity Analysis of Building Protection Factors

This Appendix was originally submitted to OCD as Research Memorandum RM 81-2,* except for minor editorial changes.

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* Edward L. Hill and Russell O. Lyday, Jr. Sensitivity Analysis of Building Protection Factors. Research Memorandum RM 81-2. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 21 September 1962.

Appendix G

Sensitivity Analysis of Building Protection Factors

I. INTRODUCTION

One of the tasks of OCD Project 1115A was to estimate probable error, or reliability, of the National Fallout Shelter Survey findings. There were a number of potential sources of error in the NBS method of computing Protection Factors (PF's) (References 1 and 2) and insufficient contract time to study all of them. To accomplish this task, it was deemed necessary to identify those sources of error likely to cause the largest variations in the calculated Protection Factor. This appendix describes a method used by RTI to identify building parameters most sensitive to change. The findings of this analysis were used to develop the list of data required to supplement NFSS Phase 1 and Phase 2 data for the RTI sample (see Part I, Chapter 4, Section III. A.).

II. PROCEDURES AND RESULTS

Input data were varied for a typical building, one element at a time, to determine resulting changes in PF. A data sheet containing all inputs necessary for the NBS PF computation was prepared for a typical building; then, data sheets were prepared which changed values assigned to the roof, walls, and partitions. Protection Factors for these buildings were computed using a computer program (Reference 3) developed at the University of North Carolina under a previous OCD contract. Original building parameters and tabulated results are found in Table G-I.

TABLE G-I

Analysis of Hypothetical Building

Protection Factors

A. Original Building Parameters

Number of Stories	4
Height of Building	48 ft.
Height of Basement	8 ft.
Length of Exterior Walls	100 ft. all sides
Basement Exposure	0 all sides
Proportion of Apertures	25% all sides-all floors
Sill Height	3 ft.
Contaminated Planes	200 ft. at 0 Ht.-all sides
Mass Thicknesses	
Roof	10#
Floors	40#
Walls (all floors)	120# all sides
Partitions (all floors)	20# all sides

B. Building Analysis

	PROTECTION FACTOR				
Floor No.	0	1	2	3	4
1. Basic Building	286	58	38	15	4
2. Add 30# - Roof	408	69	59	29	9
3. Add 10# - Partitions	328	80	50	19	5
4. Add 20# - Partitions	382	85	56	20	5
5. Add 20# - Walls	296	65	40	16	4

III. CONCLUSIONS

This analysis, as well as comparison of the NBS Computer Program with more advanced methods of calculating PF's such as the Engineering Manual, indicated that the following elements of the PF calculation procedure were likely to cause the largest variations in the PF:

A. Interior Partitions

B. Basement Exposure

C. Apertures

D. Shape Factor

REFERENCES

1. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for the National Fallout Shelter Survey. National Bureau of Standards Report No. 7539. Washington: U. S. Department of Commerce, July 1962.

2. National Bureau of Standards. Description of Computer Program for National Fallout Shelter Survey. National Bureau of Standards Report No. 7826. Washington: U.S. Department of Commerce, 15 March 1963.

3. Operations Research Division. Building Evaluation NUIT Program. RTI Internal Report C-208. Durham, North Carolina: Operations Research Division, Research Triangle Institute, December 1961.

Appendix H

Engineering Manual Ground Contribution Computational Details

I. INTRODUCTION

Building structural data from building plans, or from the data collection form (TAB 1), were used as basic inputs in the Engineering Manual (Reference 1) computations for the RTI sample of 33 buildings (see Part I, Chapter 4). Computational forms outlining the details of the Engineering Manual procedure were developed so that personnel not familiar with the Engineering Manual could compute a building PF after the basic data inputs were made. This appendix contains Engineering Manual functional equations used to develop the computational forms, samples of the forms used, and detailed instructions for their use.

II. STORIES ABOVE GRADE

For stories with the detector located above all contaminated planes, the total contribution is divided into three parts. These parts are Adjacent, Through Floor, and Through Ceiling.

A. Adjacent Contribution

1. Functional Equations

The Adjacent contribution is defined as that radiation reaching the detector through the walls and apertures of the floor being calculated. This contribution is divided into four parts which have the following functional equations.

a. Direct Contribution with Sill at or Above Detector Level

$$\frac{A_z}{360} \; B_w(X_e, H_4) \; B_w(X_i, 3') \; G_d(\omega_{\ell d}, H_4) \; [1 - S_w(X_e)]$$

$$\frac{(1)}{360} \qquad (5) \qquad (6) \qquad (25) \qquad (9)$$

b. Direct Contribution Through Apertures

$$\frac{A'_{za}}{360}\ B_w(X_i,3')\ G_d(\omega_{\ell a},H_4)\ B_w(X_e{=}0,H_4)$$

$$\frac{(72)}{360}\quad (6)\quad (71)\quad (7)$$

$$-\ \frac{A'_{za}}{360}\ G_d(\omega_{\ell a},H_4)\ B_w(X_i,3')\ \left[1-S_w(X_e)\right]\ B_w(X_e,H_4)$$

$$\frac{(72)}{360}\quad (71)\quad (6)\quad (9)\quad (5)$$

c. Scatter Contribution

$$\frac{A_z}{360}\ B_w(X_e,H_4)\ B_w(X_i,3')\ \frac{B_{ws}(\omega_s,X_e)}{B_w(X_e,H_4)}\ \left[G_s(\omega_\ell)+G_s(\omega_u)\right]\ S_w(X_e)\ E(e)$$

$$\frac{(1)}{360}\quad (5)\quad (6)\quad (51)/(5)\quad (39)\quad (41)\quad (8)\quad (52)$$

$$-\ \frac{A_{za}}{360}\ B_w(X_i,3')\ B_{ws}(\omega_s,X_e)\ G_s(\omega_{as})\ S_w(X_e)\ E(e)$$

$$\frac{(11)}{360}\quad (6)\quad (51)\quad (33d)\quad (8)\quad (52)$$

d. Skyshine Contribution

$$\frac{A_z}{360}\ B_w(X_e,H_4)\ B_w(X_i,3')\ \left[1-S_w(X_e)\right]\left[G_a(\omega_u)-P_{za}G_a(\omega_a)\right]$$

$$\frac{(1)}{360}\quad (5)\quad (6)\quad (9)\quad (18)\quad (12)\quad (31)$$

$$+\ \frac{A_{za}}{360}\ B_w(X_i,3')\ G_a(\omega_a)\ B_w(X_e{=}0,H_4)$$

$$\frac{(11)}{360}\quad (6)\quad (31)\quad (7)$$

The numbers in parentheses refer to column numbers of the computational form (Figure H-1). The symbols in the functional equations are defined in Table 5 of the Engineering Manual, except for the following:

(11) = A_{za} = degrees of aperture in the sector for scatter radiation

(72) = A_{za}' = degrees of aperture in the sector for direct radiation

(7) = $B_w(X_e=0,H_4)$ = height correction factor for height H_4

(12) = P_{za} = perimeter ratio of apertures in the wall sector

2. Adjacent Instructions

RTI produced a special form which was used to compute the adjacent contribution in a step by step procedure which could be accomplished by personnel not familiar with Engineering Manual details once the initial entries were marked. Figure H-1 shows the Adjacent Form with its headings. A special set of instructions was needed to enter the necessary initial data and to mark out sections not used in the particular sector being computed. The detailed instructions for completion of the form are as follows, with numbers in parentheses indicating form column headings:

a. For contaminated planes 2, 3, ... in a sector, set (54) = (60) = 0 and blank out (14), (15), (16), (17), (18), (26), (27), (28), (29), (31), and (53). This prevents skyshine from being computed more than once.

b. When (3) = 0, set (6) = 1.

c. If (11) = 0, set (53) = (63) = (73) = (73a) = 0 and blank out (12), (26) - (33d), (60), (61), (62), and (65)-(72).

d. If floor slab extends to exterior wall set (34) = 3'. If it doesn't, calculate (34) as in Figure H-2.

FIGURE H-1
Adjacent Form

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Sector Strip	X_e	X_1	H_4	$B_w(X_e, H_4)$	$B_w(X_1, 3')$	$B_w(X_e=0, H_4)$	$S_w(X_e)$	$1-S_w(X_e)$	(1)(5)(6)	A_{za}	P_{za}	W x L	Z_u & Z'_u	$n=2(14)/L$	$e=W/L$	ω_u & ω'_u	$G_a(\omega_u)$ or ΔG	R_ℓ
A_ℓ				Chart 2	Chart 2	Chart 2	Chart 7				(11)/(1)				See (13)	Chart 3	Chart 5	

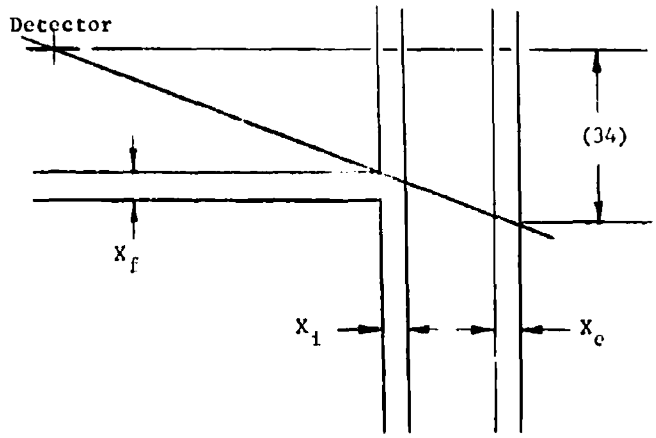
(20)	(21)	(22)	(23)	(24)	(25)	(26)	(26a)	(27)	(28)	(29)	(31)	(32)	(33)	(33a)	(33b)	(33c)	(33d)
Z_ℓ & Z'_ℓ	(19)/(20)	$1+(21)^2$	$\cos\theta = \frac{1}{\sqrt{(22)}}$	ω_ℓ & ω'_ℓ	$G_d(\omega_\ell, H_4)$	Z_a & Z'_a	W x L	$n_a = \frac{2Z_a}{L}$	$e=\frac{W}{L}$	ω_a & ω'_a	$G_a(\omega_a)$ or ΔG_a	Z_{as} & Z'_{as}	W x L	$n=\frac{2Z_{as}}{L}$	$e=\frac{W}{L}$	ω_{as} & ω'_{as}	$G_s(\omega_{as})$ or ΔG_s
	R_ℓ/Z_ℓ			= 1-(23)	or ΔG_d Chart 6		(13)			Chart 3	Chart 5		(13)			Chart 3	or ΣG_s

(34)	(35)	(36)	(37)	(38)	(39)	(40)	(40a)	(40b)	(40c)	(40d)	(41)	(42)	(43)	(44)	(45)	(46)	(47)
Z_ℓ	W x L	$n_\ell = \frac{2Z_\ell}{L}$	$e=\frac{W}{L}$	ω_ℓ	$G_s(\omega_\ell)$	Z_u	W x L	$n_u = \frac{2Z_u}{L}$	$e=\frac{W}{L}$	ω_u	$G_s(\omega'_u)$	(39)+(41)	Z_w	W_s & W'_s	S	$W=2W_s$ =	$L=S+2W_s$ =
	(13)			Chart 3	Chart 5		(13)			Chart 3	Chart 5					2(44)	(45)+(46)

(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)	(60)	(61)	(62)	(63)	(64)	(65)
$e_s = W/L$ $=\frac{(46)}{(47)}$	$n_s = 2Z/L$ $=\frac{2(43)}{(47)}$	$2\omega/\omega_s$	$B_{ws}(\omega_s, K_r)$	E(r) with e=(16)	$P_{za} G_a(\omega) \Delta G_d$	ΔG_{ap} =	$\Delta G_{ap} \Delta G_d$ =	(55) (9)	(52)(51)(42)(8)/(5)	(57)+(56)	(58)(10)	(31)(7)	(8)(33d)(51)(52)	(60)-(61)	(62)(6)/(11)	(59)+(63)	R_ℓ
		Chart 3	Chart 9	Chart 8	=(12) x (31)	(18)÷(53)	(54)+(25)										

(66)	(67)	(68)	(69)	(70)	(71)	(72)	(73)	(73a)	(74)								
$Z_{\ell a}$ & $Z'_{\ell a}$	$R_\ell/Z_{\ell a}$	$1+(67)^2$	$\cos\theta$ =	ω_ℓ & ω'_ℓ =	$G_d(\omega_\ell, H_4)$ or ΔG_d	A'_{za}	$\frac{(6)(71)}{(72)}$	$\frac{(72) \times (71)}{(1) \times (9)(10)}$	(73)+(64) -(73a)								
			$1/\sqrt{(68)}$	1 - (69)	Chart 6												

FIGURE H-2



Calculation of Z_a (34) When Floor Slab Doesn't Extend to Exterior Wall

e. Calculate the wall crossing Z's for direct, skyshine, and scatter (if necessary). These Z's define the location and width of the contaminated planes in terms of where a direct line from their edges to the detector would intersect the exterior wall.

f. Assign a code number for direct ($M_{d\infty}, M_{d1}, M_{d2}, M_{d3}$, or M_{d4}), sill level ($S_a, S_{b\infty}, S_{b1}, S_{b2}, S_{b3}, S_{b4}, S_c$, or S_d), wall scatter ($M_{s1}, M_{s2}, M_{s3}, M_{s4}$), and skyshine ($M_{a\infty}, M_a, M_{a1}, M_{a2}, M_{a3}$) (see TAB 2 for details).

g. If code is S_a, S_{b1}, or S_d, blank out (65) - (72) and set (73) = (73a) = 0.

h. Enter data in: (dimensions in feet and weight in psf)

(1) = degrees of the sector

(2) = exterior wall weight (X_e)

(3) = interior wall weight (X_i)

(4) = detector height above plane of contamination

(11) = degrees of aperture in sector

(13) = width and length of building (exterior)

(14) = distance to ceiling and distance up to height of mutual shielding (two entries if necessary)

(19) = radius out to wall at midpoint of sector

(20) = height from detector to wall crossing (direct)

(26) = window height (heights)

(32) = height of aperture struck by skyshine

(34) = height of detector above floor at exterior wall (usually 3')

(40) = wall height

(43) = height of midwall to plane of contamination

(44) = width of contaminated plane

(45) = building side length adjacent to contaminated plane

(65) = (19)

(66) = lower limits of aperture (sill below detector)

(72) = degrees of aperture through which direct passes

After these codes, modification, and entries are completed, the form is ready to be completed.

The entries in column (74) are the results of the various sectors and planes. The adjacent reduction factor is the sum of column (74) divided by 360 degrees.

B. Through Ceiling Contribution

1. Functional Equations

$$\frac{A_z}{360}\ B_w(X_i,3')B_o'(X_o')\Big[B_{ws}(\omega_s,X_e)\Delta G_s(\omega_u')S_w(X_e)E(e)\ [1-A_{ps}]$$

$\frac{(1)}{360}$ (6) (7a) (51) (41) (8) (52) (4d)

$$+\ B_w(X_e,H_u)\Delta G_a(\omega_u')\ [1-S_w(X_e)][1-A_{pa}]\ +\ B_w(X_e=0,H_4)\ A_{pa}\ \Delta G_a(\omega_u')\Big]$$

(5) (18) (9) (4g) (7) (4f) (18)

where:

(4f) = A_{pa} = fraction of aperture in skyshine contribution

(4c) = A_{ps} = fraction of aperture in scatter contribution

2. <u>Through Ceiling Instructions</u>

The form for the Through Ceiling contribution is shown in Figure H-3. The Z's used in the earlier calculation for the adjacent contribution are also used for this calculation. The special instructions for completing this form are:

a. Fill in blanks (1), (2), (3), (3a), (3b), (3f), (3h), (3i), (3k), (4), (4h), (13), (13a), (14), (39a), (40), (40a), (43), (44), and (45). [More details in m. below.]

b. Leave three lines for each contaminated plane 1, 2, - - - - .

c. For contaminated planes 2, 3, - - within a sector, set (55) = (56) = 0 and blank out (3i), (3j), (3k), (4), (4f), (4g), (7), (9), (13), (13a), (14), (15), (16), (17), and (18).

d. If infinite plane (for wall scatter), blank out (43), (45), (46), (47), (48), (49), (50), and (50a). Set (51) = (5), and set (44) = ∞.

e. When (3) = 0, set (6) = 1.0.

f. If (3k) = 0 (No skyshine through apertures), set (55) = (4f) = 0 and blank out (3i), (3j), (4), and (7).

g. If (3h) = 0, set (4c) = 0 and blank out (3f) and (3g).

h. Assign code in (13a) for mutual shielding of skyshine. Put <u>no</u> if no mutual shielding, <u>yes</u> if partially shielded or <u>comp</u> if completely shielded.

i. If (13a) is <u>comp</u>, (complete shielding of skyshine) set (55) = (56) = 0, and blank out (3i), (3j), (3k), (4f), (4g), (7), (9), (13), (14), (15), (16), (17), and (18).

FIGURE H-3
Through Ceiling Form

(1)	(2)	(3)	(3a)	(3b)	(3f)	(3g)	(3h)	(3i)	(3j)	(3k)	(4)	(4c)	(4d)	(4f)	(4g)	(4h)	(5)	(6)
Sector Strip	X_e	X_1	X'_o	L_z	$Z'_{u2}-Z_{u2}$	$A_s =$	A_{as}	$Z'_{u1}-Z_{u1}$	$A_a =$	A_{aa}	E_4	$A_{ps} =$	1-(4c)	$A_{pa} =$	1-(4f)	E_u	$B_w(X_e,E_u)$	$B_w(X_f,3')$
A_2					(see(40))	(3f)(3b)		(see(14))	(3i)(3b)			(3h)/(3g)		(3k)/(3j)			Chart 2	Chart 2

(7)	(7a)	(8)	(9)	(9a)	(13)	(13a)	(14)	(15)	(16)	(17)	(18)	(39a)	(40)	(40a)	(40b)	(40c)	(40d)
$B_w(X_e=0, E_4)$	$B'_o(X'_o)$	$S_w(X_e)$	1-(8)	(1)(6)	W x L	Code for Skyshine	Z'_u and	n=	$e = \frac{W}{L}$	ω'_u and	$G_a(\omega_u)$&	Code for wall	Z'_u and	W x L	$n_u =$	$e = \frac{W}{L}$	ω'_u and
Chart 2	Chart 1 Case 3	Chart 7		(7a)		Shielding	Z_u	2(14)/L		ω_u Chart 3	ΔG_a	scatter	Z_u		$\frac{2(40)}{L}$		ω_u

(41)	(43)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(50a)	(51)	(52)	(55)	(56)	(57)	(58)	(74)
$G_s(\omega'_u)$	Z_w	W_s &	S	$W=2W_s$	$L=S+2W_s$	$e_s=W/L=$	$\frac{2(43)}{(67)}=n_s$	$2\omega_s$	ω_s	$B_{ws}(\omega_s,$	E(e)with	(18)(7)	(18)(9)	(52)(51)	(55) +	(9a)(58)
& ΔG_s		W'_s				(46)/(47)		Chart 3		X_e) Chart 9	e=(40c)	(41)	(5)(4g)	(41)(8) (4d)	(56) + (57)	

j. Assign code in (39a) for wall scatter mutual shielding. Put no if entire upper wall is seen by direct rays from plane (no shielding). Put yes if part of upper wall is not seen by direct rays from a plane. Put comp if the wall is not struck by direct rays.

k. If (39a) is comp, set (57) = 0 and blank out (3f), (3g), (3h), (4c), (4d), (40), (40a), (40b), (40c), (40d), (41), (43), (44), (45), (46), (47), (48), (49), (50), (50a), (51), and (52).

l. If (4) = 3', set (7) = 1.0.

m. Enter data in: (dimensions in feet and weight in psf)

(1) = degrees in the sector

(2) = exterior wall weight (X_e)

(3) = interior wall weight (X_i)

(3a) = ceiling weight (X'_o) = floor above

(3b) = length of wall in sector

(3f) = vertical distance of wall seen by scatter

(3h) = area of aperture in A_s (A_{as})

(3i) = vertical distance of wall seen by skyshine

(3k) = area of aperture in A_a (A_{aa})

(4) = height of detector above plane of contamination

(4h) = height of midwall (upper story) to the plane of contamination

(13) = building size W x L (exterior)

(13a) = code for skyshine mutual shielding

(14) = Z_u's for skyshine

(39a) = code for wall scatter shielding

(40) = Z_u's for wall scatter

(40a) = (13)

(43) = (4h)

(44) = width of plane of contamination

(45) = building side length adjacent to plane of contamination

The sum of column (74) divided by 360 degrees is the reduction factor.

C. Through Floor Contribution

1. Functional Equations

The functional equations are:

$$\underset{\frac{(1)}{360}}{\frac{A_{\ell}}{360}} \underset{(6)}{B_w(X_i,3')} \underset{(7a)}{B_o(X_f)} \Big[\underset{(5)}{B_w(X_e,H_{\ell})} \underset{(25)}{\Delta G_d(\omega_{\ell d},H_4)} \underset{(9)}{[1-S_w(X_e)]} \underset{(4b)}{[1-A_{pd}]}$$

$$+ \underset{(51)}{B_{ws}(\omega_s,X_e)} \underset{(39)}{\Delta G_s(\omega_{\ell})} \underset{(8)}{S_w(X_e)} \underset{(52)}{E(e)} \underset{(4d)}{[1-A_{ps}]}$$

$$+ \underset{(25)}{G_d(\omega_{\ell d},H_4)} \underset{(7)}{B_w(X_e=0,H_4)} \underset{(4a)}{A_{pd}} \Big]$$

where :

(4a) = A_{pd} = aperture fraction through which direct contribution passes

(4c) = A_{ps} = aperture fraction through which scatter contribution would pass

2. Through Floor Instructions

The Through Floor Form is shown with its headings in Figure H-4.

The Z's as calculated in the Adjacent computation are also used in this calculation. The special set of instructions are:

FIGURE H-4

Through Floor Form

(1)	(2)	(3)	(3a)	(3b)	(3c)	(3d)	(3e)	(3f)	(3g)	(3h)	(4)	(4a)	(4b)	(4c)	(4d)	(4e)	(5)	(6)
Sector Strip	X_e	X_i	X_f	L_z	$Z'_{\ell 1}-Z_{\ell 1}$	$A_d=$	A_{ad}	$Z'_{\ell 2}-Z_{\ell 2}$	$A_s=$	A_{as}	H_4	$A_{pd}=$	1-(4a)	$A_{ps}=$	1-(4c)	H_ℓ	$B_w(X_e,H_\ell)$	$B_w(X_i,3')$
A_z					(see (20))	(3b)(3c)		(see (34))	(3f)(3b)			(3e)/(3d)		(3h)/(3g)			Chart 2	Chart 2

(1)	(7)	(7a)	(8)	(9)	(9a)	(19)	(20)	(21)	(22)	(23)	(26)	(25)	(34)	(35)	(36)	(37)	(38)	(39)
	$B_w(X_e=0,$	$B_o(X_f)$	$S_w(X_e)$	1-(8)	(1)(6)	E_ℓ	Z'_ℓ & Z_ℓ	(19)/(20)	$1+(21)^2$	$\frac{1}{\sqrt{(22)}}$	1-(23) $\omega'_\ell d$ &	$C_d(\omega_\ell,H_\ell)$ or ΔC_d	Z'_ℓ & Z_ℓ Wall	W x L	$n_\ell=\frac{2Z_\ell}{L}$	$e=\frac{W}{L}$	ω'_ℓ & ω_ℓ	$C_g(\omega_\ell)$ & $\Delta C_g(\omega_\ell)$
	$H_\ell)$ Chart2	Chart 1 Case 1	Chart 7		(7a)		(direct)				$\omega_\ell d$	Chart 6	Scatter				Chart 3	Chart 5

(1)	(43)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(50a)	(51)	(52)	(56)	(57)	(63)	(64)	(74)		
	$Z_w=(4e)$	W_s & W_s'	S	$W=2W_s$	$L=S+2W_s$	$e_s=\frac{(46)}{(47)}$	$n_s=\frac{2(43)}{(47)}$	$2\omega_s$	ω_s	$B_{ws}(\omega_s,$	E(e) with e=(37)	(25)(9)(5)(4b)	(52)(51)(39)(8)	(25)(7)(4a)	(63) + (57) +	(64)(9a)		
								Chart 3		X) or ΔB Chart	Chart 8		(4d)		(56)			

a. If no direct radiation, set (56) = (63) = 0, and blank out (3c), (3d), (3e), (4), (4a), (4b), (7), (9), (19), (20), (21), (22), (23), (24), and (25). Also blank out (5) if not an infinite field.

b. If no apertures are penetrated by direct radiation in reaching the detector, set (63) = (4a) = 0, and blank out (3c), (3d), (3e), and (7).

c. If no apertures at all, set (63) = (4a) = (4c) = 0 and blank out (3b), (3c), (3d), (3e), (3f), (3g), (3h), and (7).

d. If (3a) = 0, set (7a) = 1.

e. If (3) = 0, set (6) = 1.

f. If plane of contamination is infinite, set (51) = (5) and blank out (43) - (50).

g. For finite planes, see "Adjacent" instructions for W_s(44) and B_{ws}(51).

h. If the wall receives no scatter, set (51) = (52) = 0, and blank out (34) - (50a).

i. Enter data in: (dimensions in feet and weight in psf)

(1) = degrees in sector

(2) = exterior wall weight (X_e)

(3) = interior wall weight (X_i)

(3a) = weight of floor (X_f)

(3b) = length of wall in sector

(3c) = height of wall through which direct passes

(3e) = area of aperture in direct

(3f) = height of wall seen by scatter

(3h) = area of aperture in A_s (A_{as})

(4) = height of detector above plane of contamination

(4e) = height of midwall above plane of contamination

(19) = radius out to wall at midpoint of sector

(20) = Z_ℓ 's for direct

(34) = Z_ℓ 's for scatter

(35) = width x length

(43) = (4e)

(44) = plane width

(45) = length of building on side adjacent to plane

The reduction factor from the floor below is the total of column (74) divided by 360 degrees. It should be noted that when the detector is located on a first floor and there is no exposed basement, this contribution does not exist.

III. BASEMENT CONTRIBUTION

A. Functional Equations

The basement computation is similar to the above-ground computation. If the basement has an areaway or some other plane lower than the detector, the sectors affected are calculated with the Adjacent Form; otherwise, the following special instructions are used:

1. If basement is not exposed, use two forms: (a) the Through Ceiling Form for radiation from 2nd story and (b) the Basement Form (Figure H-5) for the radiation from 1st story.

For (a), use previous Through Ceiling Form with (4) = 3', (3a) = sum of the first and second floor weights, and (7) = 1.0.

2. If basement is partially exposed, two forms are needed: (a) Through Ceiling and (b) modified Basement. For (a), use the previous Through Ceiling Form with the following interpretation: set (4) = 3' and (7) = 1.0.

   For the modified Basement Form, use the Basement Form with the following changes:

   Set (3a) = 0, (4h) = 3, and (7a) = 1.0.

Thus the only new form is the Basement Form. This form is similar to the others and uses the following functional equations:

$$\frac{A_z}{360} B_w(X_1,3')\ B_o'(X_o')\ \Big[[1-S_w(X_c)]\ \ B_w(X_c,H_u)[\Delta G_a(\omega_u)-P_{za}\Delta G_a(\omega_a)]$$

$$\frac{(1)}{360}\quad (6)\qquad (7a)\qquad (9)\qquad (5)\qquad (18)\qquad (12)\ (31)$$

$$+ P_{za}\ \Delta G_a(\omega_a) + B_{ws}(\omega_s,X_c)S_w(X_c)E(c)\ [\Delta G_s(\omega_u)-P_{za}\ \Delta G_s(\omega_{as})]\Big] .$$

$$(12)\quad (31)\qquad (51)\qquad (8)\quad (52)\qquad (41)\qquad (12)\quad (33d).$$

B. Basement Form Instructions

The Basement Form is shown in Figure H-5. The Z's are calculated as in the other forms for blocking of skyshine. The instructions and comments on filling out the form are:

1. Fill in blanks (1), (2), (3), (3a), (4h), (11), (13), (14), (26), (32), (40), (43), (44), and (45).
2. Leave 3 lines for each plane 1, 2, 3, ...
3. For planes 2, 3, . . . in a sector, set (53) = (56) = 0 and blank out (9), (13a), (14), (15), (16), (17), (18), (25a), (26), (26a), (27), (28), (29), (31), and (54).
4. When (3) = 0, set (6) = 1.0.

FIGURE H-5
Basement Form

(1)	(2)	(3)	(3a)	(4h)	(5)	(6)	(7a)	(8)	(9)	(9a)	(11)	(12)	(13)	(13a)	(14)	(15)	(16)	(17)
Sector Strip	X_e	X_i	X'_o	H_u	$B_w(X_e, H_u)$	$B_w(X_i, 3')$	$B'_o(X'_o)$	$S_w(X_e)$	1 - (8)	(1)(6)(7a)	A'_{Z_a}	P_{Z_a} =	W x L	code for	Z'_u and	2(14)/L and	e = W/L	ω'_u and
A_g					Chart 2	Chart 2	Chart 1 Case 3	Chart 7				(11)/(1)		skyshine	Z_u	2(14)'/L		ω_u Chart 3

(18)	(25a)	(26)	(26a)	(27)	(28)	(29)	(31)	(31a)	(32)	(33)	(33a)	(33b)	(33c)	(33d)	(39a)	(40)	(40a)
$C_a(\omega'_u)$ & $\Delta C_a(\omega_u)$	Code for shielding of	Z'_a	W x L	$n'_a = \frac{2(26)}{L}$	$e = \frac{W}{L}$	ω'_a &	$C_a(\omega'_a)$ & $\Delta C_a(\omega_a)$	Code for wall scat. on	Z'_{as} &	W x L	$n' = \frac{2(32)}{L}$	$e = \frac{W}{L}$	ω'_{as} &	$C_s(\omega'_{as})$ & $\Delta C_s(\omega_{as})$	Code for Scatter	Z'_u &	W x L
Chart 5	apertures	& Z_a	(see(13))	& n_a		ω_a Chart 3	Chart 5	aperture	Z_{as}	(see(13))	and n	(see(16))	ω_{as} Chart 3	Chart 5	Shielding	Z_u	(see(13))

(40b)	(40c)	(40d)	(41)	(42a)	(43)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(50a)	(51)	(52)	(53)	(54)
$n' = \frac{2(40)}{L}$	$e = \frac{W}{L}$	ω'_u and ω_u	$C_s(\omega'_u)$ & $\Delta C_s(\omega_u)$	Code for Limited	Z_w	W_a and	S	$W = 2W_a$	$L = S + 2W_a$	$e = \frac{W}{L}$	$n = \frac{2(43)}{(47)}$	$2\omega_e$	ω_e	$E_{ws}(\omega_e, X_e)$ or ΔE_{ws}	E(e) with	(12)(31)	(18)-(53)
and n	(See (16))	Chart 3	Chart 5	Strip		W'_a						Chart 3	and ω'_e	Chart 9	e=(40c)		

(56)	(56a)	(56b)	(57)	(58)	(64)
(5)(9)	(12)(33d)	(41)-(56a)	(56b)(52)	(53)+(56)	(9a)(58)
(54)			(51)(8)	+(57)	

5. If (11) = 0, set (53) = (56a) = 0 and blank out (12), (25a), (26), (26a), (27), (28), (29), (31), (31a), (32), (33), (33a), (33b), (33c), and (33d).

6. Comments on columns:

(3a) = sum of the thicknesses (ceiling) through which the radiation passes in going from 1st floor level to detector

(4h) = height from midwall of 1st floor to average terrain level

(13) = outside W and L for Z'_u and Z_u calculation

(13a) = no if no mutual shielding of skyshine through wall

yes if partially shielded

comp if skyshine is completely blocked

If (13a) is completely shielded, set (53) = (56) = 0 and blank out (9), (14), (15), (16), (17), (18), (25a), (26), (26a), (27), (28), (29), (31), and (54).

(14) = distance from detector to ceiling of floor above (Z'_u) and distance from detector to grade level or to wall crossing at outside of building (Z_u)

(25a) = no if the skyshine through the apertures is not blocked

yes if the skyshine through the apertures is partially blocked

comp if the skyshine through the apertures is completely blocked

If (25a) is completely shielded, set (53) = 0 and blank out (26), (26a), (27), (28), (29), and (31).

(26) = distance from detector to upper sill level of 1st floor window (Z'_a) and distance from detector to either the lower sill level or the wall crossing (Z_a)

(31a) = no if entire window is seen by radiation from contaminated plane (window not blocked)

yes if the direct radiation from the plane cannot strike the entire window (partially blocked)

comp if the direct radiation from the plane does not strike the aperture (completely blocked)

If (31a) is comp, set (56a) = 0 and blank out (32), (33), (33a), (33b), (33c), and (33d).

(32) = distance from detector to upper sill level (Z'_{as}) and distance from detector to lower sill level or to wall crossing (Z_{as})

(39a) = no if entire first floor wall is hit by radiation from the plane

yes if only part of the wall is hit by radiation from the plane

comp if the wall is not hit by radiation from the plane

If (39a) is comp, set (57) = 0 and blank out (40), (40a), (40b), (40c), (40d), (41), (42a), (43), (44), (45), (46), (47), (48), (49), (50), (50a), (51), (52), and (56b).

(40) = distance from detector to ceiling (Z'_u) and distance from detector to top of 1st floor or to wall crossing (Z_u)

(42a) Assign code for wall scatter (infinite field (M_s), adjacent limited plane (M_{s1}), finite detached plane (M_{s2}), or detached infinite plane (M_{s3})).

If (42a) is M_s, let (51) = $B_w(X_e,Z_w)$ from EM Chart 2 [If $Z_w = H_u$ in (4h), $B_w(X_e,Z_w)$ will be same as (5)] and blank out (44), (45), (46), (47), (48), (49), (50), and (50a).

If (42a) is M_{s1}, use W_s in (44) and B_{ws} in (51).

If (42a) is M_{s2}, use two W_s's in (44) and ΔB_{ws} in (51).

If (42a) is M_{s3}, use one W_s' in (44), set $W_s = \infty$, with its B_{ws} in (51) equal to $B_w(X_c, Z_w)$ and calculate (51) $= B_w(X_c, Z_w) - B_{ws}(\omega_s', X_c)$.

(43) = distance from the plane to the mid-point of the region of the first floor wall that is hit by radiation. For adjacent planes, it will usually be equal to H_u in (4h). For elevated planes, it will not be.

REFERENCE

1. Office of Civil Defense. Design and Review of Structures for Protection From Fallout Gamma Radiation. (Engineering Manual). Rev. ed.; Washington: Office of Civil Defense, Department of Defense, 1 October 1961.

TAB 1

RESEARCH TRIANGLE INSTITUTE, Durham, N. C.

Fallout Shelter Data Collection Form

1. Fac.No.________ 2. Part______ of______

3. Name of Bldg.________________________

4. Address________________________

5. CT______

6. SL______

	Side A	Side B	Dist. Center from Side A	Dist. Center from Side B
7. Number of Stories				
8. Height - Total Bldg.				
- Sub-Basement				
- Basement				
- 1st Story				
- Upper Stories (avg)				
9. Length - Exterior Wall				
10. Shelter Size & Loc.				

	Side A	Side B	Side C	Side D
11. Basement Exposure				
12. Areaways - Length				
- Width				

Material & Thickness	Weight in PSF
13. Roof	
14. Floors	
-	
-	

	Side A	Side B	Side C	Side D
15. Walls				
-				
-				
-				
16. Partitions (roof)				
17. Partitions (wall)				

	Side A				Side B				Side C				Side D			
	W	Area	%	Sill	W	Area	%	Sill	W	Area	%	Sill	W	Area	%	Sill
18. Apertures Areaway																

		Side A		Side B		Side C		Side D	
		Width	Height	Width	Height	Width	Height	Width	Height
19. Contaminated Planes	1.								
	2.								
	3.								
20. Setbacks	1.								
	2.								
	3.								

TAB 2

Direct, Sill Level, Wall Scatter, and Skyshine Codes

This TAB describes the codes and program remarks necessary to complete the Adjacent Form.

Code	Remarks	Program Remarks
DIRECT		
$M_{d\infty}$	Infinite plane for direct	Use only Z_{ℓ} in (20) and $G_d(\omega_{\ell d}, H)$ in (25)
M_{d1}	No direct contribution through adjacent wall	Set (25) = 0 and blank out (19) - (24)
M_{d2}	Some direct contribution -floor shadow determines inner boundary	Calculate Z_{ℓ}' for (20) and therefore, (25) = ΔG_d
M_{d3}	Some direct contribution - both edges of plane determine boundary	Calculate Z_{ℓ} and Z_{ℓ}' for (20) and therefore, (25) = ΔG_d
M_{d4}	Some direct contribution - inner edge of plane determines boundary - other end infinite	Use only Z_{ℓ} in (20) and one G_d in (25)
DIRECT THROUGH APERTURES		
S_d	Lower sill level at detector level	Set (73)=(73a)=0 and blank out (65) - (72)
S_a	Lower sill level above detector level	Set (73)=(73a)=0 and blank out (65) - (72)
S_{b1}	Lower sill level below detector level but with no direct through the aperture	Set (73)=(73a)=0 and blank out (65) - (72)
$S_{b\infty}$	Lower sill level below detector level and infinite plane of contamination	Use one $Z_{\ell a}$ in (66) and one G_d in (71)
S_{b2}	Some direct through aperture, Z's determined by outer edge of plane and edge of aperture	Use $Z_{\ell a}$ and $Z_{\ell a}'$ in (66) and therefore, (71) = ΔG_d

TAB 2 (continued)

Code	Remarks	Program Remarks
S_{b3}	Some direct through aperture, Z's determined by edges of plane	Use $Z_{\ell a}$ and $Z'_{\ell a}$ in (66) and therefore, (71) = ΔG_d
S_{b4}	Some direct Z's determined by inner edge of plane while other edge is infinite	Use one $Z_{\ell a}$ in (66) and one G_d in (71)
S_c	All of window below detector	Use two $Z_{\ell a}$'s in (66) and therefore, (71) = ΔG_d; also, determine $Z_{\ell a}$'s by limiting considerations of window sill or edge of plane, whichever is most restrictive. If no direct, set (73)=(73a)=0 and blank out (65) - (72)
WALL SCATTER - SOLID WALL		
M_s	Infinite plane - complete wall scatter	Set (51) = (5) and blank out (43) - (50)
M_{s1}	Wall scatter from finite plane extending from building outward	Need Z_w=(43), one W_s=(44), and one B_{ws} = (31)
M_{s2}	Finite detached plane for wall scatter	Need one Z_w=(43) and two W_s in (44) and therefore, (51) = ΔB_{ws}
M_{s3}	Detached infinite plane for wall scatter	Need one Z_w=(43) and two W_s; and set $W_s = \infty$ =(44) and its B_{ws}=(51)=(5); therefore, (51) = ΔB_{ws}
M_{s4}	Plane partially blocked or entire wall is not struck by direct rays	Use Z'_{ℓ} instead of Z_{ℓ} in (34) for B_{ws}; also use same procedure as in M_{s2} (finite) or M_{s3} (infinite)

TAB 2 (continued)

Code	Remarks	Program Remarks
WALL SCATTER - APERTURES		
S_d	Lower sill level at detector height	One Z_{as} in (32) and one G_s in (33d)
S_a	Lower sill level above detector height	Need two Z_{as}'s in (32) and therefore, (33d) $= \Delta G_s$
S_b	Detector height within window opening	Need two Z_{as}'s in (32) and therefore, (33d) $= \sum G_s$
S_c	All of aperture is below detector	Need two Z_{as}'s in (32) and therefore, (33d) $= \Delta G_s$
SKYSHINE		
$M_{a\infty}$ with S_d or any S_b	No mutual shielding of skyshine	Use one Z_u (up to ceiling) in (14), one G_a in (18), one Z_a in (26), and one G_a in (31) - Z_a is from detector to actual upper edge of aperture
M_a with any S	Skyshine completely blocked by adjacent building	Set (54)=(31)=(60)=(18)=0 and blank out (14), (15), (17), and (26) - (29)
M_{a1} with any S	Skyshine partially blocked and aperture completely blocked	Set (31)=(60)=(53)=0, use two Z_u's in (14), blank out (26) - (29) ; therefore, (18) $= \Delta G_a$
M_{a2} with any S	Skyshine partially blocked and aperture partially blocked	Use Z_a and Z'_a in (26) and therefore, (31)$=\Delta G_a$; also, use Z_u and Z'_u in (14) and calculate (18)$=\Delta G_a$

TAB 2 (continued)

Code	Remarks	Program Remarks
$M_{a\infty}$ with S_a	No mutual shielding of skyshine - sill level above detector	Use one Z_u in (14), one G_a in (18), two Z_a's in (26) and calculate (31) $= \Delta G_a$
M_{a3}	Skyshine partially blocked by adjacent building - aperture not blocked above detector level	Use Z_a and Z'_a in (26) and therefore, (31) $= \Delta G_a$; also, use Z_u and Z'_u in (14) and therefore, (18) $= \Delta G_a$
S_c	All of the aperture is below detector level - no contribution for skyshine	Set (53)=(60)=0, and blank out (26), (27), (28), (29), and (31)

Appendix I

Analysis of 33-Building Sample

I. INPUT DATA AND RESULTS

A. Introduction

Computations of PF's for the 33 buildings in the sample were made in Phase 1 of the NFSS by using AE prepared FOSDIC data as inputs to the NBS-NFSS Computer Program. In Phase 2 of the NFSS, the AE adjusted the PF of some buildings by making sill height corrections or correcting mistakes made in Phase 1 data collection. RTI surveyed the buildings and submitted FOSDIC forms for processing by the NBS-NFSS Computer Program. RTI also made Engineering Manual computations for each building using more detailed input data than can be submitted on the FOSDIC form. The values used in a FOSDIC are weighted averages of sometimes up to three types of construction and mass thicknesses (psf) in one exterior wall, floor, or roof.

B. Sample Data

This section contains plan views, photographs, AE and RTI FOSDIC input data, computational results, and an analysis of input data and computational results for 32 of the sample buildings. No data are included for one building which was not surveyed by RTI because access was denied. The order and building numbers are the same as listed in Table III of Chapter 4; this table also gives the Standard Location and Facility Number for each building.

A plan view of each building is presented in each Sub-section a. to show:

Number of stories	-	number normally appears in lower left corner ("B" indicates the building has a basement).
Building height	-	number is located in the center of the building with "foot" indication. Differences in roof elevation are shown by solid lines.
Adjoining buildings	-	diagonal lines indicate immediately adjoining buildings either representing barrier-shields or elevated planes of contamination.

Each Sub-section b. shows a photograph of the exterior of the building. These photographs were originally intended for use in evaluating construction details and are also felt to be adequate to show the variations encountered in size, shape, etc.

All structural input data submitted by the AE in Phase 1 and by RTI on FOSDIC forms are contained in each Sub-section c. under each building number. The RTI-FOSDIC column represents data collected by RTI in accordance with Phase 1 instructions, except that all significant partitions are accounted for. RTI submitted FOSDIC forms listing only masonry load-bearing and fire-break partitions (Phase 1 instructions) and FOSDIC forms listing all significant partitions in order to determine the effect of omitted partitions. The data used in making Engineering Manual calculations are not reported because up to 19 azimuthal sectors were required to define the variations in construction and contaminated planes. As many as three different wall weights might be encountered on a single building side, whereas only one wall weight per side can be reported on the FOSDIC form.

Listed in each Sub-section d. are the PF's and reduction factors determined for the buildings in the RTI sample. The terms used are defined as follows:

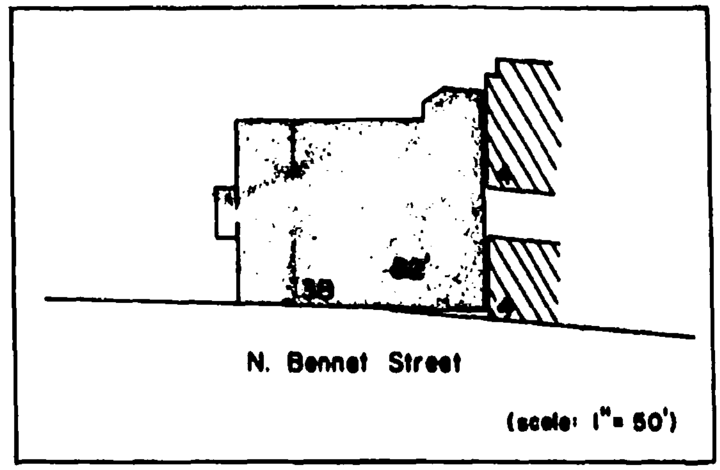
Detector Location	- floor and building part (as shown in the "RTI FOSDIC" column of building data in each Sub-section c.) for which data are reported.
AE Phase 1	- results from NBS-NFSS Computer Program.
AE Phase 2	- results from NFSS Phase 2.
RTI FOSDIC (No X_i)	- results from NBS-NFSS Computer Program using RTI submitted FOSDIC form without interior partitions considered.
RTI FOSDIC (X_i)	- results from NBS-NFSS Computer Program using RTI submitted FOSDIC form with interior partitions.
RTI EM	- results from detailed Engineering Manual calculation.

The reduction factors calculated by the NFSS Computer Program were rounded to three decimal places such as 0.017 and 0.008. Since protection factors are more commonly used, these are also presented. PF's are the reciprocals of reduction factors with rounding carried out only to the nearest whole number, i.e., 1/0.017 = 59 and 1/0.008 = 125. The reduction factors are therefore better to use in comparing AE Phase 1 and RTI FOSDIC individual building results because of the ease in determining the correct range of values (e.g., .008 = .008 $\pm$ .0005). The Engineering Manual reduction factors were calculated by RTI to three significant figures and the corresponding protection factors were rounded to whole numbers.

An analysis of the more important differences in input data submitted by the AE in Phase 1 and collected by RTI for each of the sample buildings is contained in each Sub-section e. Input differences not affecting the floor under consideration are not enumerated but can be determined by comparing tabular data in each Sub-section c. Also listed are differences between the NBS-NFSS Computer Program procedure and the Engineering Manual method judged to have been principally responsible for the difference in PF for the specific building analyzed.

1. **Address:** 30-32 North Bennet Street, Boston, Mass.

   a. Plan View



   b. Photograph

c. Data Inputs

Address 30-32 North Bennet Street, Boston, Massachusetts

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		04 B	3 B
2.	Height-Total Building		060	62
3.	Length-Exterior Wall	A	080	80
4.		B	060	59
5.	Basement Exposure	A	4	3
6.		B	4	3
7.		C	4	3
8.		D	0	3
9.	PSF-Roof		80	60
10.	Basement Floor		-	-
11.	First Floor		70	100
12.	Upper Floor		70	100
13.	Basement X_e	A	220	360
14.		B	220	300
15.		C	220	520
16.		D	220	300
17.	Walls-First X_e	A	130	130
18.		B	130	130
19.		C	130	130
20.		D	150	130
21.	-Upper X_e	A	130	130
22.		B	130	130
23.		C	130	130
24.		D	150	130
25.	-Upper X_e	A	4th 100	3rd 100
26.	(if a change)	B	4th 100	3rd 100
27.		C	4th 100	3rd 100
28.		D	4th 100	3rd 100
29.	Partitions-Basement	A	0	0
30.		B	0	150
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	100
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	100
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	10
42.		B	10	0
43.		C	10	0
44.		D	0	0
45.	-First	A	30	20
46.		B	10	10
47.		C	10	20
48.		D	0	0
49.	-Upper	A	30	20
50.		B	20	10
51.		C	30	10
52.		D	0	0
53.	-Upper	A	4th 0	-
54.	(if a change)	B	4th 0	3rd 20
55.		C	4th 0	3rd 20
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 2, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	67	.014	.001	.015
Phase 2.	96	.005425	.005	.010425
RTI FOSDIC (No X_i)	77	.010	.003	.013
FOSDIC (X_i)	83	.009	.003	.012
EM	116	.0044	.0042	.0086

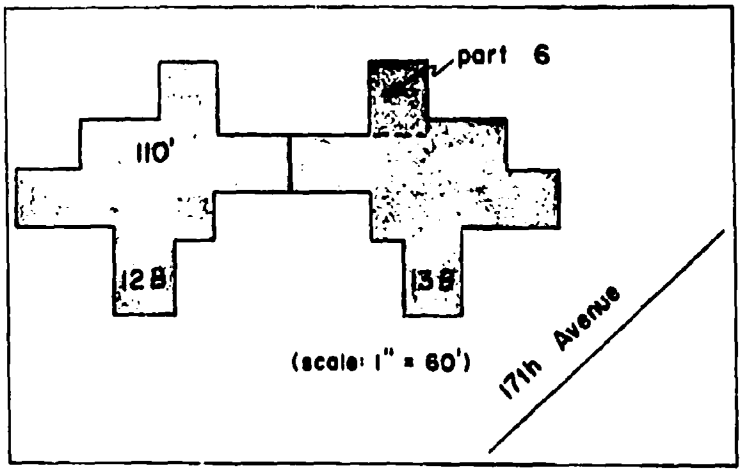
e. Analysis of Differences

(1) Input Data - The AE reported 4 stories in Phase 1 instead of the actual 3 but corrected this in Phase 2. Adjustments were also made in Phase 2 for the 6½ foot sills and for a 12 inch brick partition which brought the PF very close to the EM result. The differences in data not corrected by the AE were variations of at least 10 percent in apertures, a 20 psf higher estimate of roof weight, and 30 psf lower weight for first and upper floors than determined by RTI from building plans.

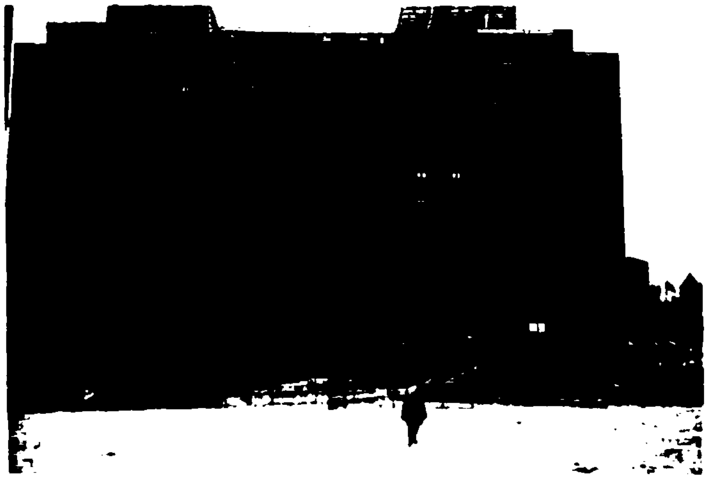
(2) Procedures - Primary differences were the blocking of radiation by the high sills and the floor slab. This building also had a large skylight in the roof which could not be handled accurately by the NBS computer method.

2. Address: 73-77 Seventeenth Avenue, Newark, N. J.

a. Plan View



b. Photograph



c. Data Inputs

Address 73-77 Seventeenth Avenue, Newark, N. J.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		13 B	13 B
2.	Height-Total Building		109	110
3.	Length-Exterior Wall	A	022	22
4.		B	026	26
5.	Basement Exposure	A	4	4
6.		B	3	4
7.		C	4	4
8.		D	4	4
9.	PSF-Roof		60	60
10.	Basement Floor		-	-
11.	First Floor		60	60
12.	Upper Floor		60	60
13.	Basement X_e	A	140	150
14.		B	140	150
15.		C	140	150
16.		D	140	150
17.	Walls-First X_e	A	80	80
18.		B	80	80
19.		C	80	80
20.		D	80	80
21.	-Upper X_e	A	80	80
22.		B	80	80
23.		C	80	80
24.		D	80	80
25.	-Upper X_e	A	0	0
26.	(if a change)	B	0	0
27.		C	0	0
28.		D	0	0
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	10	0
42.		B	10	10
43.		C	10	10
44.		D	10	10
45.	-First	A	20	0
46.		B	20	20
47.		C	20	20
48.		D	20	20
49.	-Upper	A	20	0
50.		B	20	20
51.		C	20	20
52.		D	20	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 9, Part 6 of 8

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	50	.020	0	.020
Phase 2.	No Change			
RTI FOSDIC (No X_i)	31	.032	0	.032
EM	69	.0144	0	.0144

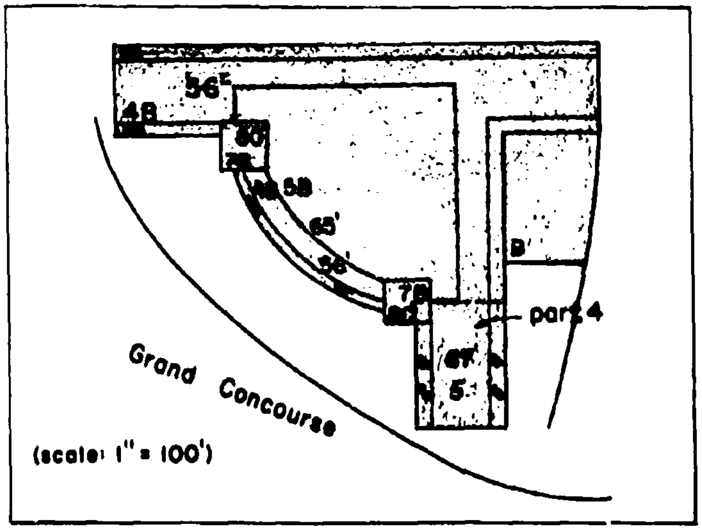
e. Analysis of Differences

(1) Input Data - Only a very minor difference of 10 psf occurred in the upper exterior wall. Extreme differences were noted in the first planes (grade level) on the C and D sides. RTI observed widths were 450 and 240 feet, whereas the AE values were only 70 and 60 feet respectively.

(2) Procedures - The EM PF and AE Phase 1 PF are very close due to the simple building construction involved. The increase in EM PF is due primarily to shielding of direct radiation by the floor slab.

3. Address: 650 Grand Concourse, Bronx, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 650 Grand Concourse, Bronx, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		05	5
2.	Height-Total Building		068	67
3.	Length-Exterior Wall	A	060	60
4.		B	083	82
5.	Basement Exposure	A	-	-
6.		B	-	-
7.		C	-	-
8.		D	-	-
9.	PSF-Roof		60	50
10.	Basement Floor		-	-
11.	First Floor		-	-
12.	Upper Floor		60	80
13.	Basement X_e	A	-	-
14.		B	-	-
15.		C	-	-
16.		D	-	-
17.	Walls-First X_e	A	120	130
18.		B	120	170
19.		C	180	160
20.		D	120	120
21.	-Upper X_e	A	120	140
22.		B	120	120
23.		C	120	160
24.		D	120	120
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	-	-
30.		B	-	-
31.		C	-	-
32.		D	-	-
33.	-First	A	0	0
34.		B	0	60
35.		C	0	20
36.		D	0	30
37.	-Upper	A	0	0
38.		B	0	20
39.		C	0	20
40.		D	0	20
41.	% Apertures-Basement	A	-	-
42.		B	-	-
43.		C	-	-
44.		D	-	-
45.	-First	A	0	0
46.		B	0	0
47.		C	0	0
48.		D	20	30
49.	-Upper	A	20	10
50.		B	20	50
51.		C	0	0
52.		D	20	50
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 1, Part 4 of 9

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	59	.016	.001	.017
Phase 2.	300	.002	.001	.003
RTI FOSDIC (No X_i)	43	.023	0	.023
FOSDIC (X_i)	91	.011	0	.011
EM	164	.0061	0	.0061

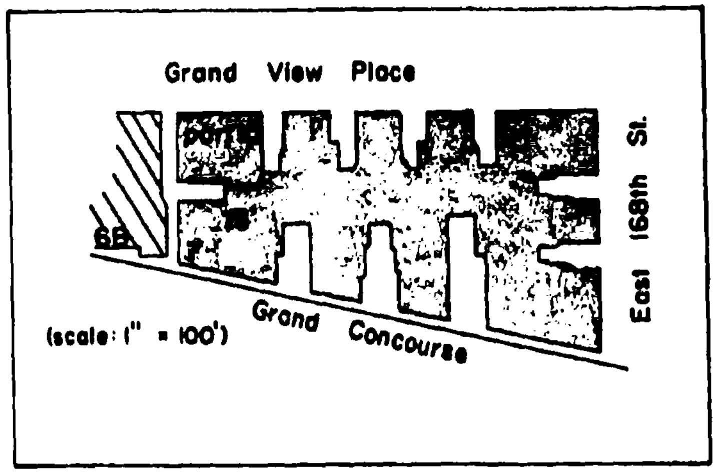
e. Analysis of Differences

(1) Input Data - The AE estimate was lower for the upper floors by 20 psf and for the upper floor apertures by an average of 20 percent. The PF was adjusted by the AE in Phase 2 for an 80 psf partition and for sill height. However, Phase 2 instructions indicate that when X_i is greater than 40 psf, no sill height correction should be made. This double adjustment accounts for the large increase in PF when compared to the EM result.

(2) Procedures - The difference in RTI FOSDIC PF and EM PF is attributed to the sill correction and handling of irregular planes of contamination by 20 azimuthal sectors. This building is located on top of a hill with a slope of approximately 45°, which is difficult to account for in the computer method.

4. Address: 1235 Grand Concourse, Bronx, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 1235 Grand Concourse, Bronx, New York

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		07	7
2.	Height-Total Building		072	73
3.	Length-Exterior Wall	A	055	55
4.		B	045	46
5.	Basement Exposure	A	-	-
6.		B	-	-
7.		C	-	-
8.		D	-	-
9.	PSF-Roof		20	10
10.	Basement Floor		-	-
11.	First Floor		-	-
12.	Upper Floor		20	10
13.	Basement X_e	A	-	-
14.		B	-	-
15.		C	-	-
16.		D	-	-
17.	Walls-First X_e	A	150	240
18.		B	150	240
19.		C	150	160
20.		D	150	160
21.	-Upper X_e	A	120	130
22.		B	120	130
23.		C	120	130
24.		D	120	130
25.	-Upper X_e	A	-	3rd 100
26.	(if a change)	B	-	3rd 100
27.		C	-	3rd 100
28.		D	-	3rd 100
29.	Partitions-Basement	A	-	-
30.		B	-	-
31.		C	-	-
32.		D	-	-
33.	-First	A	0	20
34.		B	0	20
35.		C	0	20
36.		D	0	20
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	-	-
42.		B	-	-
43.		C	-	-
44.		D	-	-
45.	-First	A	10	20
46.		B	10	20
47.		C	20	30
48.		D	10	20
49.	-Upper	A	10	10
50.		B	10	20
51.		C	20	20
52.		D	10	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 3, Part 10 of 10

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	100	.003	.007	.010
Phase 2.	No Change			
RTI FOSDIC (No X_i)	45	.005	.017	.022
EM	66	.0039	.0113	.0152

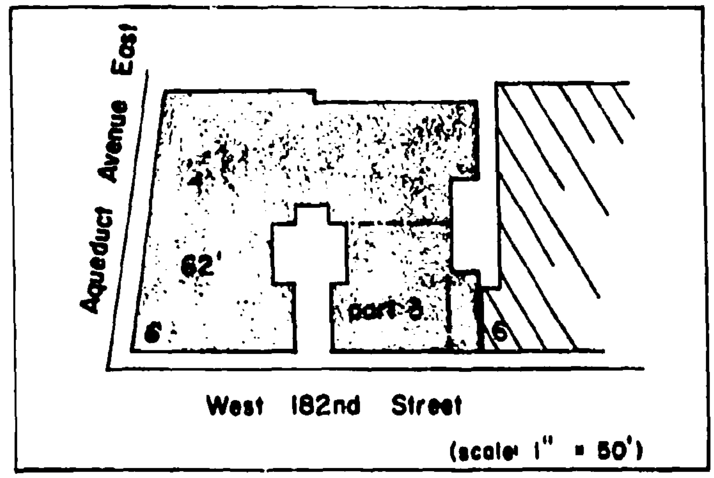
e. Analysis of Differences

(1) Input Data - A 20 psf reduction of X_e at the third floor was not noted on the NFSS Phase 1 FOSDIC and the percent of upper floor apertures was 10 percent less on this form. The most significant difference, however, due to the major roof contribution, was the difference in upper floor and the roof weights (20 psf for AE and 10 psf for RTI).

(2) Procedures - A difference in roof contribution is noticeable because of the influence of the shape of the building. The small difference in ground contribution is attributed to the sill height correction.

5. **Address:** 81 West 182nd Street, Bronx, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 81 West 182nd Street, Bronx, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		05 B	6
2.	Height-Total Building		050	62
3.	Length-Exterior Wall	A	040	40
4.		B	050	48
5.	Basement Exposure	A	7	-
6.		B	7	-
7.		C	7	-
8.		D	7	-
9.	PSF-Roof		10	10
10.	Basement Floor		-	-
11.	First Floor		50	-
12.	Upper Floor		10	10
13.	Basement X_c	A	200	-
14.		B	200	-
15.		C	180	-
16.		D	200	-
17.	Walls-First X_c	A	160	130
18.		B	160	130
19.		C	130	160
20.		D	160	160
21.	-Upper X_c	A	120	100
22.		B	120	100
23.		C	90	70
24.		D	120	100
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	3rd 60
28.		D	-	-
29.	Partitions-Basement	A	0	-
30.		B	0	-
31.		C	0	-
32.		D	0	-
33.	-First	A	0	0
34.		B	0	0
35.		C	0	160
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	60
40.		D	0	0
41.	% Apertures-Basement	A	20	-
42.		B	10	-
43.		C	0	-
44.		D	10	-
45.	-First	A	20	30
46.		B	20	10
47.		C	0	0
48.		D	10	10
49.	-Upper	A	20	30
50.		B	20	20
51.		C	0	0
52.		D	10	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 1, Part 3 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	59	.013	.004	.017
Phase 2.	PF Cat. 4 - AE did not show computations			
RTI FOSDIC (No X_i)	21	.040	.007	.047
FOSDIC (X_i)	23	.037	.007	.044
EM	45	.0143	.0080	.0223

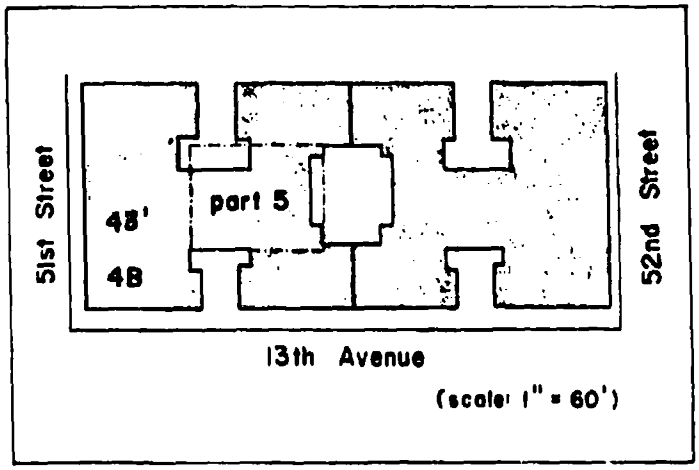
e. Analysis of Differences

(1) Input Data - The AE counted 5 stories and RTI counted 6 because of complete exposure of the basement wall. The first floor was listed by the AE as 50 psf whereas this weight floor did not extend over the part of the building analyzed. AE estimates for the basement X_e were also from 20 - 70 psf higher than RTI values for the first floor (equivalent data because of the way the lowest story was handled) and the aperture percentage was 10 percent lower for one wall. Very good plans were available for this building.

(2) Procedures - Very narrow strips of contamination and sills at detector level resulted in shielding of most of the direct radiation.

6. Address: 5101-23 13th Avenue, Brooklyn, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 5101-23 13th Ave., Brooklyn, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		04 B	4 B
2.	Height-Total Building		037	43
3.	Length-Exterior Wall	A	035	42
4.		B	040	37
5.	Basement Exposure	A	9	4
6.		B	9	4
7.		C	9	4
8.		D	3	4
9.	PSF-Roof		10	10
10.	Basement Floor		-	-
11.	First Floor		10	10
12.	Upper Floor		10	10
13.	Basement X_e	A	60	50
14.		B	60	190
15.		C	60	190
16.		D	190	200
17.	Walls-First X_e	A	50	50
18.		B	50	50
19.		C	50	50
20.		D	130	100
21.	-Upper X_e	A	30	30
22.		B	30	30
23.		C	30	30
24.		D	120	100
25.	-Upper X	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	10	10
45.	-First	A	0	0
46.		B	0	0
47.		C	0	0
48.		D	20	20
49.	-Upper	A	0	0
50.		B	0	0
51.		C	0	0
52.		D	20	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 5 of 6

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	48	.008	.013	.021
Phase 2.	No Change			
RTI FOSDIC (No X_i)	63	.005	.011	.016
EM	65	.0029	.0126	.0155

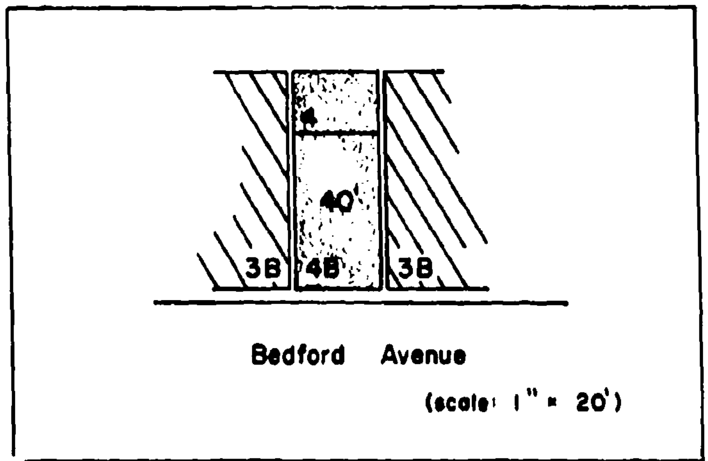
e. Analysis of Differences

(1) Input Data - Basement exposure on the AE Phase 1 FOSDIC was 9 feet for 3 sides and 3 feet for the fourth. RTI had 4 feet for all 4 sides, indicating an error by the AE in transcribing data to the form. The basement X_c was also 130 psf lower than the RTI entry for 2 sides and 30 psf higher for a third side.

(2) Procedures - Partially exposed basements have a major contribution from direct radiation when calculated by the Computer Program. This contribution is eliminated by EM procedures when the detector is below grade. This inclusion of excessive direct radiation by the computer accounts for the closeness of the FOSDIC and EM PF's.

7. Address: 485 Bedford Avenue, Brooklyn, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 485 Bedford Ave., Brooklyn, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		04 B	4 B
2.	Height-Total Building		042	40
3.	Length-Exterior Wall	A	017	19
4.		B	048	47
5.	Basement Exposure	A	0	0
6.		B	7	0
7.		C	0	0
8.		D	7	0
9.	PSF-Roof		10	10
10.	Basement Floor		-	-
11.	First Floor		10	10
12.	Upper Floor		10	10
13.	Basement X_e	A	290	60
14.		B	300	70
15.		C	290	60
16.		D	300	70
17.	Walls-First X_e	A	160	120
18.		B	170	70
19.		C	160	60
20.		D	170	70
21.	-Upper X_e	A	160	120
22.		B	170	70
23.		C	160	60
24.		D	170	70
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	40	30
46.		B	20	0
47.		C	40	30
48.		D	0	0
49.	-Upper	A	40	30
50.		B	10	0
51.		C	30	30
52.		D	0	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	140	0	.007	.007
Phase 2.	200	.002	.003	.005
RTI FOSDIC (No X_i)	67	.006	.009	.015
EM	147	.0006	.0062	.0068

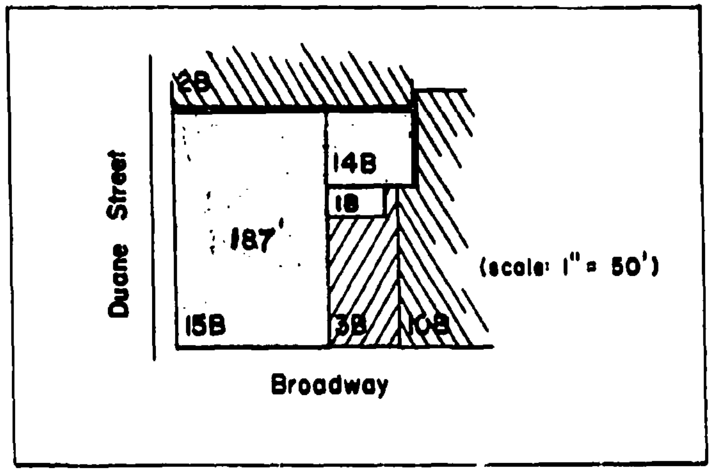
e. Analysis of Differences

(1) Input Data - This basement was completely unexposed but the Phase 1 FOSDIC indicated 7 feet exposure on 2 sides. This error was offset, however, by calling the X_e = 300 psf. Contaminated planes were also reported such that the basement was still calculated by the computer as being unexposed. The AE data for the first story X_e were 100 psf greater on 3 sides and 40 psf greater on the fourth than RTI data.

(2) Procedures - This building helps to verify the statement in the Computer Program description that says "Present experimental evidence indicates that protection factors calculated for basements with no exposure may be somewhat optimistic." The Phase 1 result almost equals the EM PF and the Phase 2 modification makes it higher than the EM PF.

8. **Address:** 304 Broadway, Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 304 Broadway, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		15 B	15 B
2.	Height-Total Building		202	187
3.	Length-Exterior Wall	A	047	47
4.		B	108	110
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		40	70
10.	Basement Floor		70	140
11.	First Floor		70	140
12.	Upper Floor		70	140
13.	Basement X_c	A	120	300
14.		B	120	300
15.		C	320	280
16.		D	200	280
17.	Walls-First X_c	A	120	160
18.		B	120	160
19.		C	320	220
20.		D	200	220
21.	-Upper X_c	A	120	150
22.		B	120	150
23.		C	200	120
24.		D	160	120
25.	-Upper X	A	-	7th 130
26.	(if a change)	B	-	7th 130
27.		C	3rd 160	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	30
34.		B	0	30
35.		C	0	0
36.		D	0	30
37.	-Upper	A	0	30
38.		B	0	30
39.		C	0	0
40.		D	0	30
41.	% Apertures-Basement	A	-	-
42.		B	10	-
43.		C	-	-
44.		D	-	-
45.	-First	A	10	20
46.		B	10	20
47.		C	0	0
48.		D	0	0
49.	-Upper	A	30	30
50.		B	30	30
51.		C	0	0
52.		D	10	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	9th 10
56.		D	-	7th 10

d. Results of PF Computations

Detector Location: Floor 8, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	125	.008	0	.008
Phase 2.	No Change			
RTI FOSDIC (No X_1)	83	.012	0	.012
FOSDIC (X_1)	125	.008	0	.008
EM	278	.0036	0	.0036

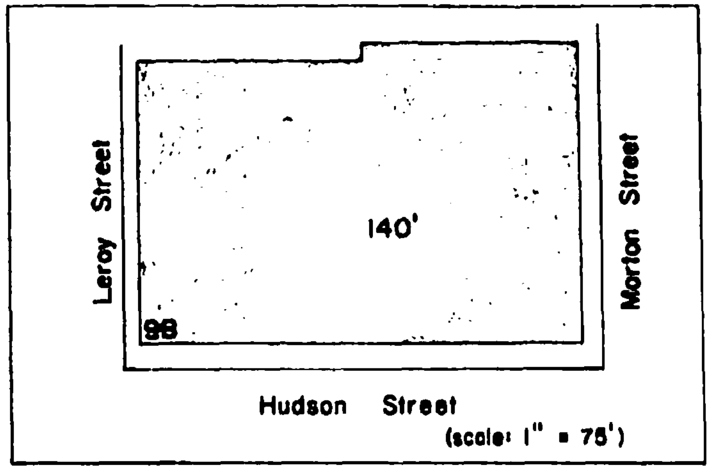
e. Analysis of Differences

(1) Input Data - Data on the AE Phase I FOSDIC and RTI FOSDIC with partitions varied for almost every element, yet the errors are compensating so that the PF's are the same.

(2) Procedures - Major differences in RTI FOSDIC and EM results are due to limited planes shielded by the floor slab and sills in extremely heavy walls.

9. **Address:** 435 Hudson Street, Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 435 Hudson Street, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		09 B	9 B
2.	Height-Total Building		140	140
3.	Length-Exterior Wall	A	198	200
4.		B	123	122
5.	Basement Exposure	A	0	2
6.		B	0	3
7.		C	0	3
8.		D	0	3
9.	PSF-Roof		60	60
10.	Basement Floor		-	-
11.	First Floor		70	70
12.	Upper Floor		70	70
13.	Basement X_c	A	120	510
14.		B	120	510
15.		C	120	240
16.		D	120	510
17.	Walls-First X_c	A	0	140
18.		B	0	140
19.		C	0	100
20.		D	0	140
21.	-Upper X_c	A	120	140
22.		B	120	140
23.		C	120	100
24.		D	120	100
25.	-Upper X_c	A	-	3rd 100
26.	(if a change)	B	-	3rd 100
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	10
42.		B	0	10
43.		C	0	0
44.		D	10	10
45.	-First	A	60	40
46.		B	60	50
47.		C	0	0
48.		D	60	50
49.	-Upper	A	40	40
50.		B	40	40
51.		C	10	0
52.		D	40	40
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	4th 30	4th 20
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	42	.024	0	.024
Phase 2.	196	.00509	0	.00509
RTI FOSDIC (No X_1)	53	.019	0	.019
EM	125	.0080	0	.0080

e. Analysis of Differences

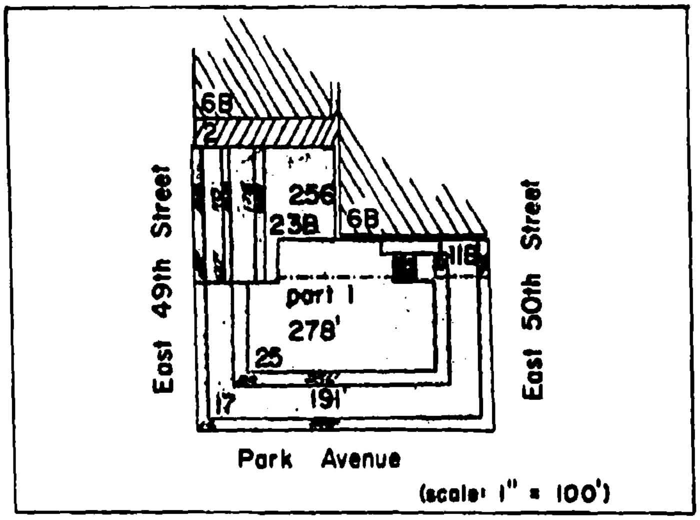
(1) Input Data - The difference in AE Phase 1 and RTI FOSDIC PF's is due to the height of the third plane of contamination reported for the "C" side. The RTI data places the plane above detector level for the fourth floor and the AE data indicate that it is below the detector level. This plane is quite important because the first two planes are only a total of 50 feet wide, and the computer calculates an extrapolated contribution for sources beyond the third plane when all reported planes are below detector level (EXTRAP Procedure). Other input data affecting the fourth floor were quite close except for an additional 10% apertures reported on this same side by the AE. An error not affecting the fourth floor was an indication of 0 psf first floor walls by the AE.

Application of both interior partition and sill corrections in Phase 2 led to a PF higher than the EM result.

(2) Procedures - Shielding of some direct radiation by floors and sills and some skyshine by adjacent buildings results in the increase in EM PF.

10. Address: 300 Park Avenue, Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 300 Park Avenue, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		25	25
2.	Height-Total Building		278	278
3.	Length-Exterior Wall	A	200	200
4.		B	095	95
5.	Basement Exposure	A	-	-
6.		B	-	-
7.		C	-	-
8.		D	-	-
9.	PSF-Roof		60	60
10.	Basement Floor		-	-
11.	First Floor		-	-
12.	Upper Floor		60	60
13.	Basement X_e	A	-	-
14.		B	-	-
15.		C	-	-
16.		D	-	-
17.	Walls-First X_e	A	80	40
18.		B	80	40
19.		C	240	40
20.		D	80	40
21.	-Upper X_e	A	80	40
22.		B	80	40
23.		C	80	20
24.		D	80	40
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	-	-
30.		B	-	-
31.		C	-	-
32.		D	-	-
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	-	-
42.		B	-	-
43.		C	-	-
44.		D	-	-
45.	-First	A	90	80
46.		B	70	80
47.		C	0	0
48.		D	80	80
49.	-Upper	A	60	60
50.		B	60	60
51.		C	50	0
52.		D	60	60
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	53	.019	0	.019
Phase 2.	Cat. 4	No justification given		
RTI FOSDIC (No X_1)	48	.021	0	.021
EM	275	.00363	0	.00363

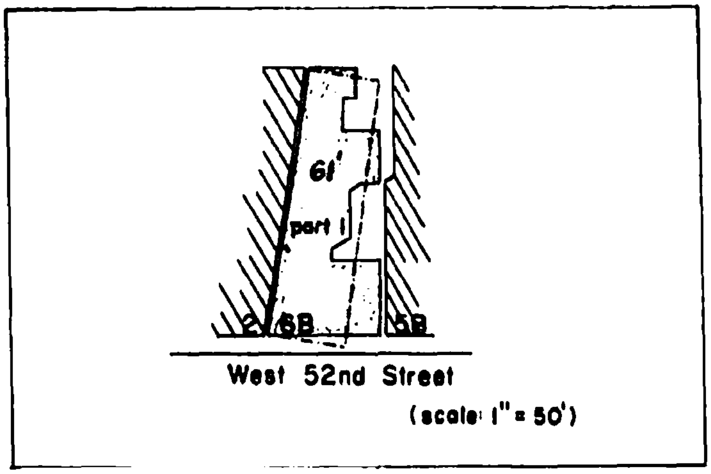
e. Analysis of Differences

(1) Input Data - Phase 1 data indicate 50 percent apertures on C wall whereas Phase 1 instructions indicate X_c should be adjusted for apertures when the building is divided into parts. Upper X_o is higher on Phase 1 FOSDIC by 40 psf for 3 walls and 60 psf for fourth.

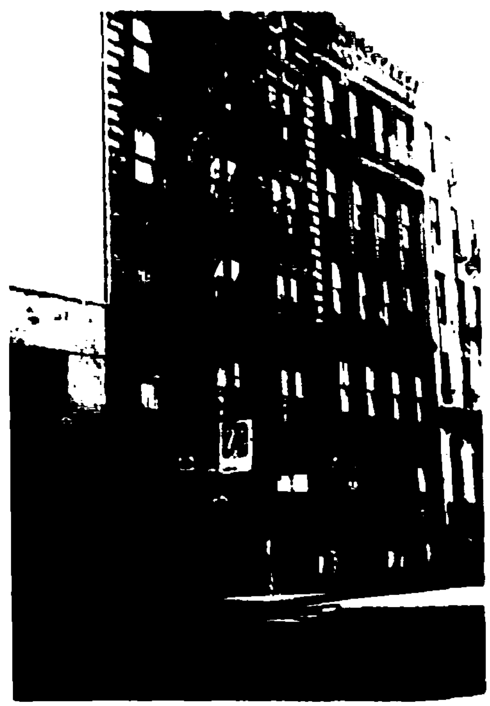
(2) Procedures - This building is very tall and surrounded by equally tall ones. From the center of the fourth floor one can see neither ground not sky without "seeing" multiple floors. This is a good example of the need to make separate calculations for direct, scattered, and skyshine radiation because different amounts of each are encountered. The NFSS Computer Program treats all three elements of radiation as a group and does not allow for reduction of any one or two without reducing them all.

11. Address: 362 W. 52nd Street, Manhattan, N.Y.C.

a. Plan View



b. Photograph



c. Data Inputs

Address 362 W. 52nd St., N. Y. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		06 B	6 B
2.	Height-Total Building		062	61
3.	Length-Exterior Wall	A	020	27
4.		B	090	88
5.	Basement Exposure	A	0	1
6.		B	0	1
7.		C	0	1
8.		D	0	1
9.	PSF-Roof		10	10
10.	Basement Floor		-	-
11.	First Floor		60	10
12.	Upper Floor		10	10
13.	Basement X_e	A	290	130
14.		B	290	130
15.		C	290	130
16.		D	290	130
17.	Walls-First X_e	A	130	130
18.		B	130	130
19.		C	130	130
20.		D	130	130
21.	-Upper X_e	A	130	130
22.		B	100	100
23.		C	100	100
24.		D	100	100
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	90	90
46.		B	0	0
47.		C	40	10
48.		D	0	10
49.	-Upper	A	40	30
50.		B	0	0
51.		C	40	20
52.		D	0	10
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 2, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	42	.010	.014	.024
Phase 2.	No Change			
RTI FOSDIC (No X_i)	36	.010	.018	.028
EM	73	.0079	.0058	.0137

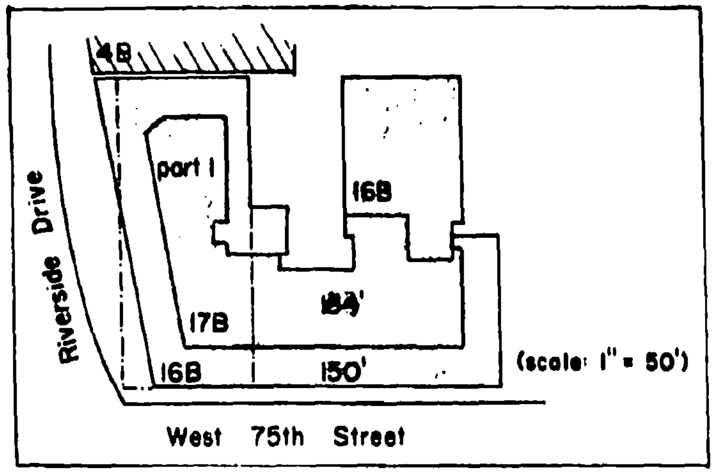
e. Analysis of Differences

(1) Input Data - Inputs were fairly close except for an additional 7 feet indicated by RTI for the building width. This extra width accounted for the larger RTI FOSDIC roof contribution.

(2) Procedures - Roof contribution was much smaller in the EM method because of the odd shape of the building.

12. Address: 327 W. 75th Street, Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 327 W. 75th St., N. Y. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		17 B	17 B
2.	Height-Total Building		152	164
3.	Length-Exterior Wall	A	100	35
4.		B	040	102
5.	Basement Exposure	A	0	0
6.		B	1	2
7.		C	0	0
8.		D	0	11
9.	PSF-Roof		50	70
10.	Basement Floor		-	-
11.	First Floor		50	60
12.	Upper Floor		50	60
13.	Basement X_e	A	140	90
14.		B	140	90
15.		C	140	90
16.		D	100	90
17.	Walls-First X_e	A	100	90
18.		B	100	90
19.		C	100	90
20.		D	70	90
21.	-Upper X_e	A	100	90
22.		B	100	90
23.		C	100	90
24.		D	70	90
25.	-Upper X	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	20
34.		B	0	20
35.		C	0	20
36.		D	0	40
37.	-Upper	A	0	20
38.		B	0	20
39.		C	0	20
40.		D	0	40
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	10
45.	-First	A	40	30
46.		B	40	30
47.		C	0	0
48.		D	0	10
49.	-Upper	A	40	30
50.		B	40	30
51.		C	0	0
52.		D	0	10
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	8th 10	6th 10
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	63	.016	0	.016
Phase 2.	No Change			
RTI FOSDIC (No X_i)	53	.019	0	.019
FOSDIC (X_i)	71	.014	0	.014
EM	292	.00343	0	.00343

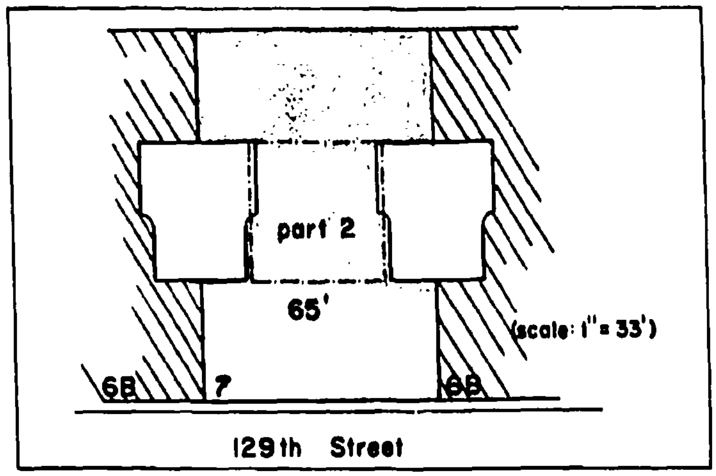
e. Analysis of Differences

(1) Input Data - An entry error was made on the AE Phase 1 FOSDIC which interchanged the A and B building dimensions. This error caused the worst contamination to be located on the smaller side, thereby overestimating the PF. A number of partitions were not counted by the AE, but the exterior walls were estimated as 10 psf heavier on 3 sides and 20 psf lighter on the fourth.

(2) Procedures - Over half of the skyshine was shielded by tall buildings and a large part of the direct from narrow planes was shielded by a 60 psf floor. These facts account for the large increase of the EM PF over the RTI FOSDIC PF.

13. Address: 47-49 W. 129th Street, Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 47-49 West 129th St., N. Y. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		06 B	7
2.	Height-Total Building		063	72
3.	Length-Exterior Wall	A	025	26
4.		B	035	37
5.	Basement Exposure	A	2	-
6.		B	2	-
7.		C	2	-
8.		D	2	-
9.	PSF-Roof		20	10
10.	Basement Floor		-	-
11.	First Floor		20	-
12.	Upper Floor		20	20
13.	Basement X_e	A	100	-
14.		B	130	-
15.		C	60	-
16.		D	120	-
17.	Walls-First X_e	A	100	170
18.		B	120	190
19.		C	60	170
20.		D	120	190
21.	-Upper X_e	A	100	90
22.		B	120	120
23.		C	60	90
24.		D	120	120
25.	-Upper X_e	A	-	3rd 70
26.	(if a change)	B	-	3rd 90
27.		C	-	3rd 70
28.		D	-	3rd 90
29.	Partitions-Basement	A	0	-
30.		B	0	-
31.		C	0	-
32.		D	0	-
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	-
42.		B	10	-
43.		C	0	-
44.		D	10	-
45.	-First	A	0	0
46.		B	30	20
47.		C	0	0
48.		D	30	20
49.	-Upper	A	0	0
50.		B	30	20
51.		C	0	0
52.		D	30	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 1, Part 2 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	250	.003	.001	.004
Phase 2.	No Change			
RTI FOSDIC (No X_1)	53	.019	0	.019
EM	379	.00121	.00143	.00264

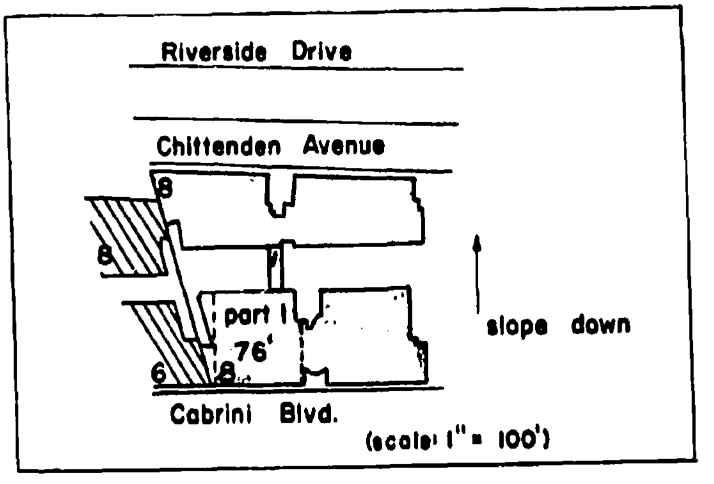
e. Analysis of Differences

(1) Input Data - This was the only building in which a Phase 1 PF as high as 250 was evaluated. It was done in this case in order to evaluate the effect of areaways which were across the entire front and back of the building. In addition, both sides of the building had courtyards at the same level as the areaways, which were at floor level of the lowest story. This floor was reported as a basement by the AE and as the first story by RTI. Contaminated planes were reported by the AE in such a manner that the lowest floor (AE Basement) was considered as being 8 feet below grade, when in reality this floor was exactly at grade level.

(2) Procedures - There is a large difference noted between RTI FOSDIC and EM results essentially because of the very narrow planes (20 feet) and heavy walls up to detector level. Skyshine was also completely shielded by adjoining buildings.

14. Address: 360 Cabrini Blvd., Manhattan, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 360 Cabrini Blvd., Manhattan, N. Y. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		8	8
2.	Height-Total Building		078	76
3.	Length-Exterior Wall	A	060	60
4.		B	060	66
5.	Basement Exposure	A	-	-
6.		B	-	-
7.		C	-	-
8.		D	-	-
9.	PSF-Roof		20	40
10.	Basement Floor		-	-
11.	First Floor		-	-
12.	Upper Floor		20	70
13.	Basement X_e	A	-	-
14.		B	-	-
15.		C	-	-
16.		D	-	-
17.	Walls-First X_e	A	220	130
18.		B	220	130
19.		C	220	130
20.		D	220	130
21.	-Upper X_e	A	150	130
22.		B	150	130
23.		C	150	130
24.		D	150	130
25.	-Upper X_e	A	3rd 110	3rd 100
26.	(if a change)	B	3rd 110	3rd 100
27.		C	3rd 110	3rd 100
28.		D	3rd 110	3rd 100
29.	Partitions-Basement	A	-	-
30.		B	-	-
31.		C	-	-
32.		D	-	-
33.	-First	A	0	130
34.		B	0	0
35.		C	0	0
36.		D	0	130
37.	-Upper	A	0	130 - 60*
38.		B	0	0 - 60*
39.		C	0	0 - 60*
40.		D	0	130 - 60*
41.	% Apertures-Basement	A	-	-
42.		B	-	-
43.		C	-	-
44.		D	-	-
45.	-First	A	20	0
46.		B	10	10
47.		C	20	20
48.		D	10	0
49.	-Upper	A	30	0
50.		B	20	10
51.		C	30	20
52.		D	20	0
53.	-Upper	A	30	3rd 30
54.	(if a change)	B	20	-
55.		C	30	-
56.		D	20	3rd 10

* Changes to 60 at 3rd floor.

d. Results of PF Computations

Detector Location: Floor 1, Part 1 of 4

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	71	.012	.002	.014
Phase 2.	No Change			
RTI FOSDIC (No X_1)	110	.009	0	.009
FOSDIC (X_1)	125	.008	0	.008
EM	556	.0018	0	.0018

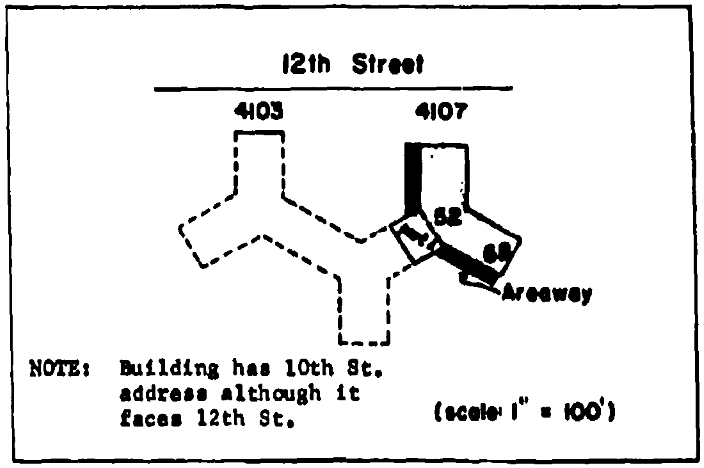
e. Analysis of Differences

(1) Input Data - The AE Phase 1 roof contribution was caused by roof and floor weights being estimated 20 and 50 psf, respectively, less than RTI. AE Phase 1 data indicated 20 percent apertures on the first story A side which was completely underground and 10 percent on the D side which had 0 percent. Omitted in Phase 1 were 130 psf partitions on the A and D sides, but the X_e entry for all walls was 220 psf compared to 130 for RTI. The X_e may have been meant to account for the omitted partition weight.

(2) Procedures - Direct contribution through the aperture in Phase 1 was the major contribution and was significantly reduced in the EM PF by the heavy wall under the sill level and the fact that there were no apertures as reported by the AE on the D side.

15. **Address:** 4107 10th Street, Queens, N.Y.C.

a. Plan View



b. Photograph

c. Data Inputs

Address 4107 Tenth Street, Queens, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		06 B	6 B
2.	Height-Total Building		056	52
3.	Length-Exterior Wall	A	030	27
4.		B	030	30
5.	Basement Exposure	A	4	4
6.		B	0	4
7.		C	4	4
8.		D	9	4
9.	PSF-Roof		60	60
10.	Basement Floor		-	-
11.	First Floor		60	60
12.	Upper Floor		60	60
13.	Basement X_e	A	150	150
14.		B	150	80
15.		C	150	150
16.		D	150	80
17.	Walls-First X_e	A	90	100
18.		B	90	80
19.		C	90	100
20.		D	90	80
21.	-Upper X_e	A	90	100
22.		B	90	80
23.		C	90	100
24.		D	90	80
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	20	10
42.		B	0	0
43.		C	20	10
44.		D	0	0
45.	-First	A	30	30
46.		B	0	0
47.		C	30	30
48.		D	0	0
49.	-Upper	A	30	30
50.		B	0	0
51.		C	30	30
52.		D	0	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	50	.020	0	.020
Phase 2.	No Change			
RTI FOSDIC (No X_1)	91	.011	0	.011
EM	212	.00472	0	.00472

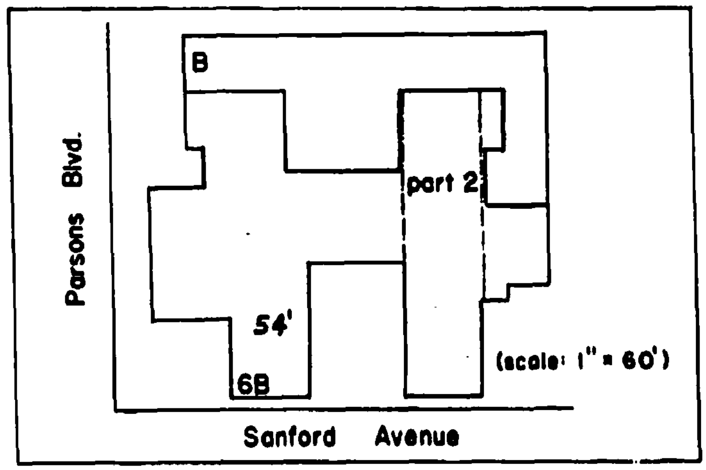
e. Analysis of Differences

(1) Input Data - The only noticeable differences were an indication by the AE of 10 percent more for the A and C basement apertures and 10 psf lighter first story walls for the A and C sides. These variations made considerable difference because the first planes of contamination on these sides were 260 feet for the A side and 160 feet for the C.

(2) Procedures - The percent of apertures difference stated above is quite significant because of the direct radiation figured in a partially exposed basement through the use of Chart 3 of the AE Guide. The contribution through the solid wall portion is also considerably overestimated through the use of this Chart. The EM method considerably reduces this contribution.

16. Address: 14415 Sanford Avenue, Queens, N.Y.C.

a. Plan View



b. Photograph

NO PHOTOGRAPH AVAILABLE

c. Data Inputs

Address 14415 Sanford Avenue, Queens, New York City

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		06 B	6 B
2.	Height-Total Building		054	54
3.	Length-Exterior Wall	A	040	40
4.		B	120	120
5.	Basement Exposure	A	6	6
6.		B	3	4
7.		C	0	2
8.		D	2	3
9.	PSF-Roof		20	20
10.	Basement Floor		-	-
11.	First Floor		70	20
12.	Upper Floor		20	20
13.	Basement X_c	A	180	130
14.		B	180	130
15.		C	180	160
16.		D	180	130
17.	Walls-First X_c	A	80	80
18.		B	80	80
19.		C	80	80
20.		D	80	80
21.	-Upper X_c	A	80	80
22.		B	80	80
23.		C	80	80
24.		D	80	80
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	80
30.		B	0	80
31.		C	0	80
32.		D	0	80
33.	-First	A	0	60
34.		B	0	60
35.		C	0	60
36.		D	0	60
37.	-Upper	A	0	40
38.		B	0	40
39.		C	0	40
40.		D	0	40
41.	% Apertures-Basement	A	10	10
42.		B	10	10
43.		C	0	0
44.		D	10	10
45.	-First	A	20	10
46.		B	20	20
47.		C	20	20
48.		D	20	10
49.	-Upper	A	20	10
50.		B	20	20
51.		C	20	20
52.		D	20	10
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 2 of 2

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	125	.006	.002	.008
Phase 2.	No Change			
RTI FOSDIC (No X_i)	59	.010	.007	.017
FOSDIC (X_i)	125	.001	.007	.008
EM	161	.0045	.0017	.0062

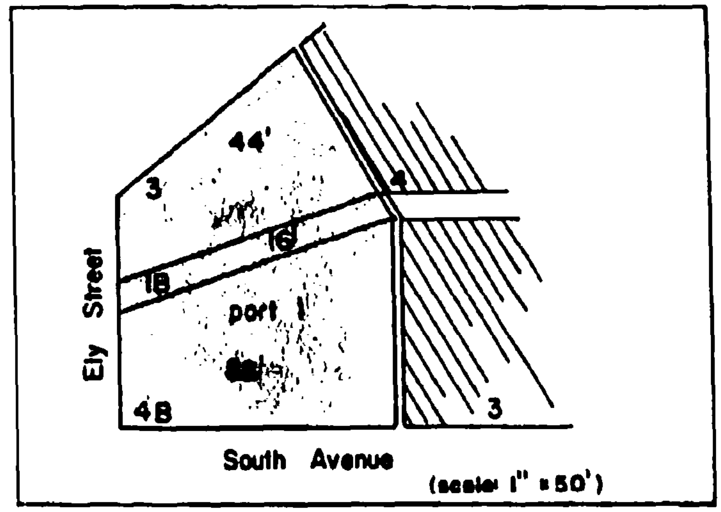
e. Analysis of Differences

(1) Input Data - The end PF result using the RTI and Phase 1 FOSDICS are the same, although the roof and ground contributions using one FOSDIC are quite different from results of the other. The AE Phase 1 FOSDIC indicated 50 psf higher values for three basement walls, 50 psf higher for the 1st floor, and did not count major partitions in the basement.

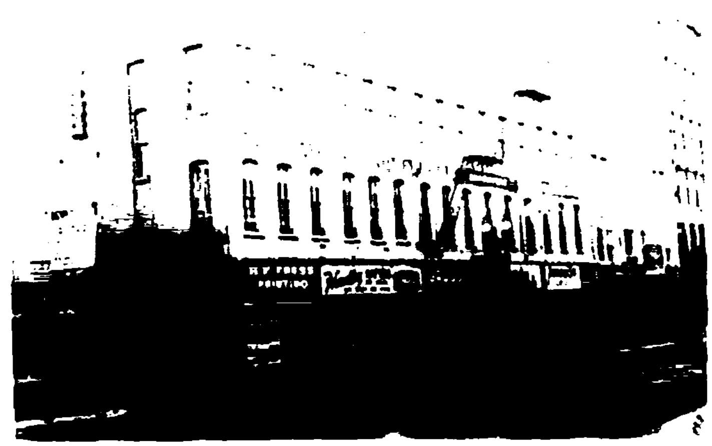
(2) Procedures - The EM PF was higher than the RTI FOSDIC PF primarily due to excessive direct radiation calculated by the Computer Program for partially exposed basements as stated before.

17. Address: 37-49 South Avenue, Rocherter, I.

a. Plan View



b. Photograph



c. Data Inputs

Address 37-49 South Avenue, Rochester, New York

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		4 B	4 B
2.	Height-Total Building		048	52
3.	Length-Exterior Wall	A	094	94
4.		B	054	54
5.	Basement Exposure	A	0	0
6.		B	8	4
7.		C	9	9
8.		D	8	0
9.	PSF-Roof		20	10
10.	Basement Floor		-	-
11.	First Floor		20	10
12.	Upper Floor		20	10
13.	Basement X_e	A	310	200
14.		B	310	200
15.		C	160	240
16.		D	310	200
17.	Walls-First X_e	A	160	130
18.		B	160	130
19.		C	160	30
20.		D	170	130
21.	-Upper X_e	A	160	100
22.		B	160	100
23.		C	160	100
24.		D	140	100
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	3rd 120	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	90
31.		C	0	0
32.		D	0	200
33.	-First	A	0	0
34.		B	0	90
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	10	10
43.		C	10	0
44.		D	0	0
45.	-First	A	90	90
46.		B	0	10
47.		C	20	0
48.		D	0	0
49.	-Upper	A	40	40
50.		B	10	10
51.		C	40	30
52.		D	0	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	3rd 20	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 2

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	77	.002	.011	.013
Phase 2.	No Change			
RTI FOSDIC (X_1)	37	0	.027	.027
EM	47	.0024	.0190	.0214

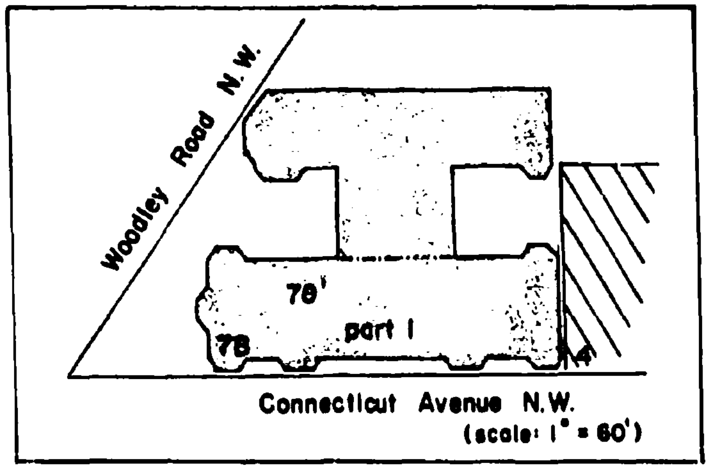
e. Analysis of Differences

(1) Input Data - Floor and roof weights were listed as 10 psf higher in the Phase 1 FOSDIC which is quite critical because 90 percent of the total contribution is from the roof. The difference in ground contribution between the AE Phase 1 and RTI FOSDIC was caused by the AE's estimating the C wall as 80 psf lower than RTI (160 to 240 psf).

(2) Procedures - Little difference in EM and Computer Program in procedures for roof contribution is the reason for close results between EM and RTI FOSDIC data. Very heavy walls and partitions make ground contribution negligible.

18. Address: 2700 Connecticut Avenue, Washington, D. C.

a. Plan View



b. Photograph

c. Data Inputs

Address 2700 Connecticut Ave., Washington, D. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		07 B	7 B
2.	Height-Total Building		070	70
3.	Length-Exterior Wall	A	140	137
4.		B	042	46
5.	Basement Exposure	A	5	4
6.		B	5	5
7.		C	5	3
8.		D	5	4
9.	PSF-Roof		60	20
10.	Basement Floor		-	-
11.	First Floor		60	40
12.	Upper Floor		60	40
13.	Basement X_e	A	120	180
14.		B	120	180
15.		C	120	180
16.		D	120	180
17.	Walls-First X_e	A	120	160
18.		B	120	160
19.		C	120	160
20.		D	120	160
21.	-Upper X_e	A	120	110
22.		B	120	110
23.		C	120	110
24.		D	120	110
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	80
30.		B	0	80
31.		C	0	80
32.		D	0	80
33.	-First	A	0	0
34.		B	0	20
35.		C	0	20
36.		D	0	20
37.	-Upper	A	50	20
38.		B	50	20
39.		C	50	20
40.		D	50	20
41.	% Apertures-Basement	A	10	30
42.		B	10	30
43.		C	10	20
44.		D	20	30
45.	-First	A	50	30
46.		B	50	20
47.		C	40	20
48.		D	60	20
49.	-Upper	A	50	20
50.		B	50	20
51.		C	40	20
52.		D	60	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	77	.012	.001	.013
Phase 2.	120	.0072	.001	.0082
RTI FOSDIC (X_1)	53	.013	.006	.019
EM	164	.0040	.0021	.0061

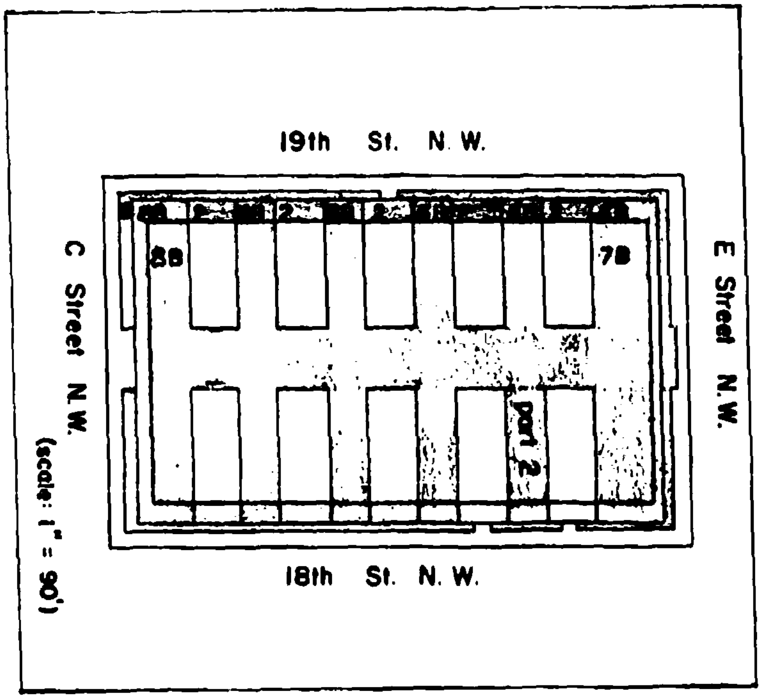
e. Analysis of Differences

(1) Input Data - AE Phase 1 floor and roof psf's are considerably heavier than RTI data; the upper X_c is 10 psf higher; the interior partitions are 30 psf higher; and the upper story percent apertures are 20 - 30 percent higher.

(2) Procedures - Major differences in procedures causing the increased EM PF are sill height correction and contribution from a peripheral roof.

19. Address: 18th and C Streets, Washington, D. C.

a. Plan View



b. Photograph

c. Data Inputs

Address 18th & C Streets, Washington, D. C.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		07 B	8 B
2.	Height-Total Building		087	95
3.	Length-Exterior Wall	A	157	157
4.		B	051	51
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		100	100
10.	Basement Floor		-	-
11.	First Floor		110	100
12.	Upper Floor		110	100
13.	Basement X_c	A	160	160
14.		B	160	160
15.		C	160	160
16.		D	290	290
17.	Walls-First X_c	A	150	130
18.		B	150	180
19.		C	150	130
20.		D	230	230
21.	-Upper X_c	A	150	130
22.		B	150	180
23.		C	150	130
24.		D	230	230
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	6th 140
27.		C	-	-
28.		D	6th 150	6th 150
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	30
34.		B	0	30
35.		C	0	30
36.		D	0	30
37.	-Upper	A	0	30
38.		B	0	30
39.		C	0	30
40.		D	0	30
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	30	30
46.		B	30	0
47.		C	30	20
48.		D	30	20
49.	-Upper	A	30	30
50.		B	30	0
51.		C	30	30
52.		D	30	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	6th 10	6th 10

d. Results of PF Computations

Detector Location: Floor 3, Part 2 of 19

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	125	.008	0	.008
Phase 2.	No Change			
RTI FOSDIC (No X_1)	125	.008	0	.008
FOSDIC (X_1)	330	.003	0	.003
EM	1080	.00092	0	.00092

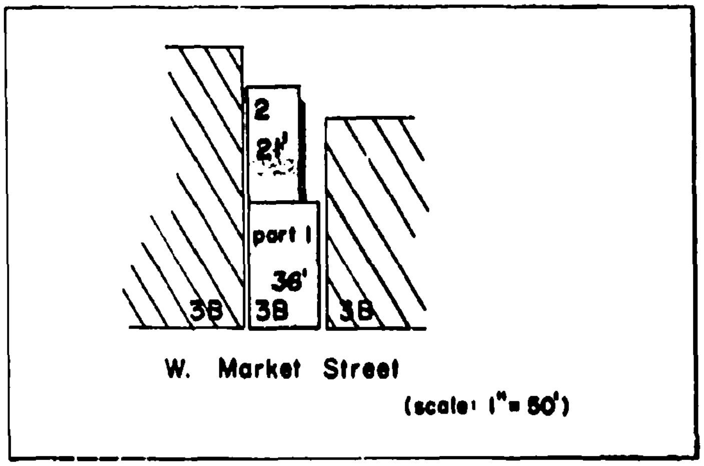
e. Analysis of Differences

(1) Input Data - The AE counted 1 too many stories and did not count 30 psf partitions. His estimates for percent apertures were also 10 percent higher on 1 side and 30 percent higher on another side. AE exterior wall weights were 20 psf heavier on 2 sides and 30 psf lighter on a third side.

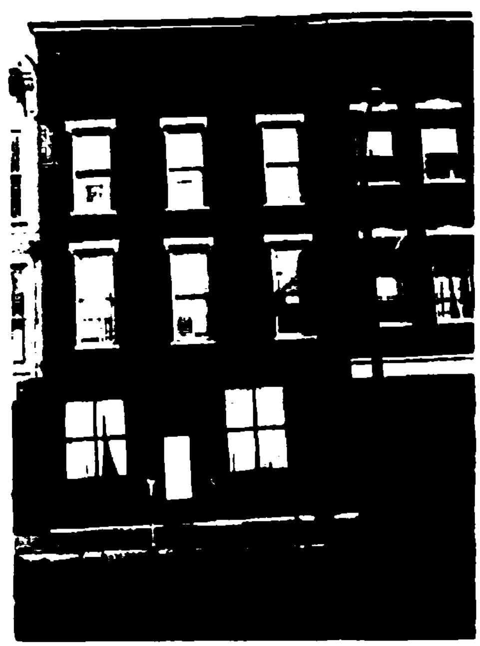
(2) Procedures - Because of mutual shielding and sill heights, there is almost no direct or skyshine contribution which accounts for the very high EM PF.

20. Address: 1011 W. Market Street, Louisville, Ky.

a. Plan View



b. Photograph



c. Data Inputs

Address 1011 W. Market Street, Louisville, Ky.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		03 B	3 B
2.	Height-Total Building		037	36
3.	Length-Exterior Wall	A	021	23
4.		B	040	45
5.	Basement Exposure	A	0	1
6.		B	0	1
7.		C	0	1
8.		D	0	1
9.	PSF-Roof		10	10
10.	Basement Floor		-	-
11.	First Floor		10	10
12.	Upper Floor		10	10
13.	Basement X_e	A	200	100
14.		B	200	100
15.		C	200	100
16.		D	200	100
17.	Walls-First X_e	A	0	120
18.		B	120	100
19.		C	160	100
20.		D	120	100
21.	-Upper X_e	A	120	60
22.		B	120	60
23.		C	120	60
24.		D	120	60
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	-
30.		B	0	-
31.		C	0	-
32.		D	0	-
33.	-First	A	0	-
34.		B	0	-
35.		C	0	-
36.		D	0	-
37.	-Upper	A	0	-
38.		B	0	-
39.		C	0	-
40.		D	0	-
41.	% Apertures-Basement	A	20	20
42.		B	0	0
43.		C	10	10
44.		D	0	0
45.	-First	A	90	80
46.		B	0	0
47.		C	20	20
48.		D	0	0
49.	-Upper	A	30	30
50.		B	0	0
51.		C	20	20
52.		D	0	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	71	.003	.011	.014
Phase 2.	No Change			
RTI FOSDIC (No X_1)	42	.008	.016	.024
EM	71	.0011	.013	.0141

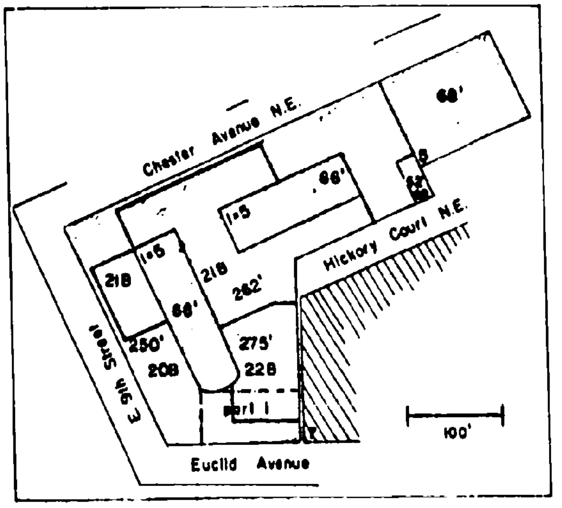
e. Analysis of Differences

(1) Input Data - The small amount of basement exposure (1 foot) was ignored by the AE in Phase 1, yet a percent of apertures was indicated for sides A and C. Basement walls were indicated as 200 psf by the AE and 100 psf by RTI.

(2) Procedures - Differences in EM PF and RTI FOSDIC PF were due to the small difference attributed to shape factor being accounted for in roof contribution and the partially exposed basement situation mentioned above.

21. **Address:** 917 Euclid Avenue, Cleveland, Ohio

a. Plan View



b. Photograph

c. Data Inputs

Address 917 Euclid Ave., Cleveland, Ohio

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		22 B	22 B
2.	Height-Total Building		275	275
3.	Length-Exterior Wall	A	095	110
4.		B	053	57
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		60	120
10.	Basement Floor		-	-
11.	First Floor		120	130
12.	Upper Floor		120	100
13.	Basement X_e	A	120	250
14.		B	120	250
15.		C	110	250
16.		D	220	250
17.	Walls-First X_e	A	120	250
18.		B	120	250
19.		C	10	250
20.		D	140	250
21.	-Upper X_e	A	120	150
22.		B	120	150
23.		C	20	150
24.		D	180	150
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	5th 110	-
28.		D	5th 110	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	30
38.		B	0	30
39.		C	0	30
40.		D	0	30
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	40	40
46.		B	40	0
47.		C	0	0
48.		D	0	0
49.	-Upper	A	40	40
50.		B	40	0
51.		C	0	0
52.		D	0	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	5th 40	5th 20
56.		D	9th 40	10th 20

d. Results of PF Computations

Detector Location: Floor 5, Part 1 of 8

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	59	.017	0	.017
Phase 2.	110	.009	0	.009
RTI FOSDIC (No X_1)	250	.004	0	.004
FOSDIC (X_1)	500	.002	0	.002
EM	455	.0022	0	.0022

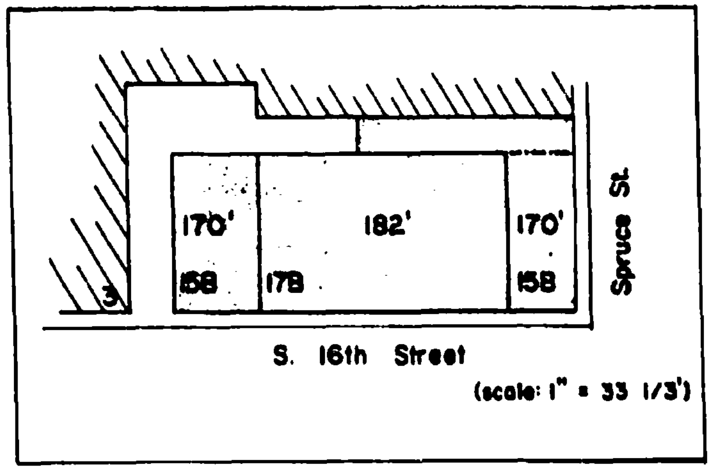
e. Analysis of Differences

(1) Input Data - Interior partitions were not counted by the AE in Phase 1, and the RTI X_e is 30 psf higher on 2 sides and 30 psf lighter on the third side. On the fourth side, the AE Phase 1 X_e was only 20 psf and the RTI entry was 150 psf, which indicates that the 20 psf is apparently an error in transcribing data from notes to the FOSDIC. Phase 1 instructions for dividing buildings (multiple interior partitions in the adjoining building part were counted and the X_e adjusted for apertures) accounted for the very high RTI FOSDIC PF. The length of the exterior wall on the A side was also 15 feet longer in the RTI data.

(2) Procedures - This is felt to be a good example of the problems that can be encountered when it is necessary to divide a building into parts for the computer. This building also had most of its direct and skyshine partially shielded by adjacent buildings in the EM calculation.

22. Address: 257 S. 16th Street, Philadelphia, Pa.

a. Plan View



b. Photograph

c. Data Inputs

Address 257 S. 16th St., Philadelphia, Pennsylvania

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		17 B	17 B
2.	Height-Total Building		188	182
3.	Length-Exterior Wall	A	085	78
4.		B	035	40
5.	Basement Exposure	A	3	4
6.		B	3	4
7.		C	0	4
8.		D	3	4
9.	PSF-Roof		40	10
10.	Basement Floor		90	110
11.	First Floor		90	110
12.	Upper Floor		90	110
13.	Basement X_e	A	160	140
14.		B	160	140
15.		C	160	120
16.		D	160	140
17.	Walls-First X_e	A	120	120
18.		B	120	120
19.		C	120	90
20.		D	120	120
21.	-Upper X_e	A	120	120
22.		B	120	120
23.		C	120	90
24.		D	120	120
25.	-Upper X	A	10th 80	10th 80
26.	(if a change)	B	10th 80	10th 80
27.		C	10th 80	10th 60
28.		D	10th 80	10th 80
29.	Partitions-Basement	A	0	20
30.		B	0	20
31.		C	0	20
32.		D	0	20
33.	-First	A	0	20
34.		B	0	20
35.		C	0	20
36.		D	0	20
37.	-Upper	A	0	20
38.		B	0	20
39.		C	0	20
40.		D	0	20
41.	% Apertures-Basement	A	40	40
42.		B	50	20
43.		C	50	20
44.		D	50	20
45.	-First	A	40	30
46.		B	50	20
47.		C	20	20
48.		D	50	20
49.	-Upper	A	40	40
50.		B	50	20
51.		C	30	30
52.		D	50	30
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 9, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	40	.025	0	.025
Phase 2.	No Change			
RTI FOSDIC (No X_1)	43	.023	0	.023
FOSDIC (X_1)	56	.018	0	.018
EM	250	.0040	0	.0040

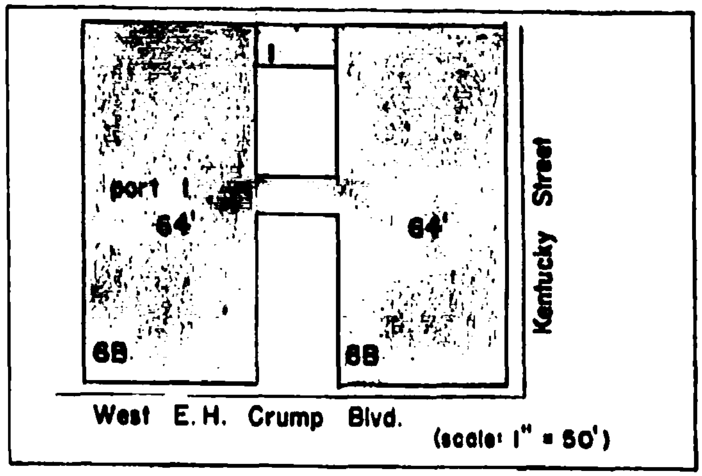
e. Analysis of Differences

(1) Input Data - The RTI data indicates 20 psf partitions on all sides; 30 percent less apertures on the B side; and 20 percent less apertures on the D side resulting in a higher RTI FOSDIC (X_1) PF than the NFSS Phase 1 PF.

(2) Procedures - Since the detector was placed on a high floor, a large part of the direct radiation was shielded by the floor slab and sills which resulted in a much higher EM PF.

23. Address: 70 West E. H. Crump Blvd., Memphis, Tenn.

a. Plan View



b. Photograph

c. Data Inputs

Address 70 West E. H. Crump Blvd., Memphis, Tenn.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		6 B	6 B
2.	Height-Total Building		67	64
3.	Length-Exterior Wall	A	60	60
4.		B	145	145
5.	Basement Exposure	A	3	3
6.		B	2	3
7.		C	3	3
8.		D	3	3
9.	PSF-Roof		160	150
10.	Basement Floor		-	-
11.	First Floor		150	140
12.	Upper Floor		150	140
13.	Basement X_e	A	450	100
14.		B	200	100
15.		C	200	100
16.		D	200	100
17.	Walls-First X_e	A	160	100
18.		B	130	100
19.		C	130	100
20.		D	130	100
21.	-Upper X_e	A	120	100
22.		B	120	100
23.		C	120	100
24.		D	120	100
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	300	0
30.		B	0	0
31.		C	160	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	20
42.		B	60	50
43.		C	20	40
44.		D	20	10
45.	-First	A	20	20
46.		B	30	40
47.		C	60	70
48.		D	20	20
49.	-Upper	A	20	20
50.		B	20	30
51.		C	30	20
52.		D	20	10
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	3rd 0	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 2

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	56	.018	0	.018
Phase 2.	100	.010	0	.010
RTI FOSDIC (No X_1)	42	.024	0	.024
EM	62	.0161	0	.0161

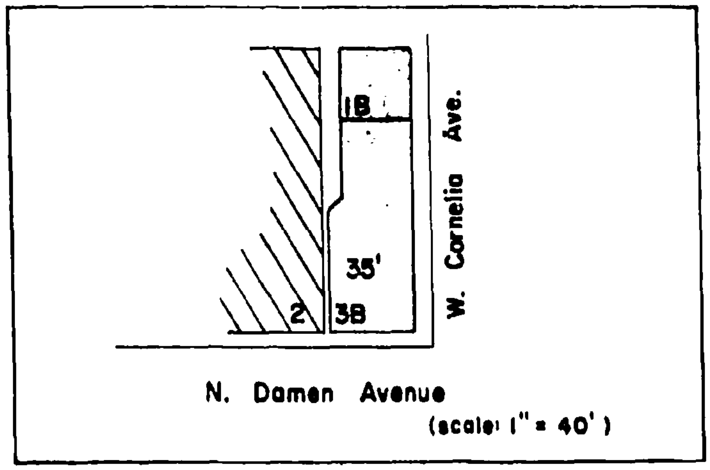
e. Analysis of Differences

(1) Input Data - The only significant input difference affecting the fourth story was an indication of wall weights 20 psf higher for all sides on the AE Phase 1 than on the RTI FOSDIC.

(2) Procedures - The sill height correction was the only major procedural difference causing the variation in PF between the RTI FOSDIC and the EM.

24. Address: 3456 N. Damen Avenue, Chicago, Ill.

a. Plan View



b. Photograph

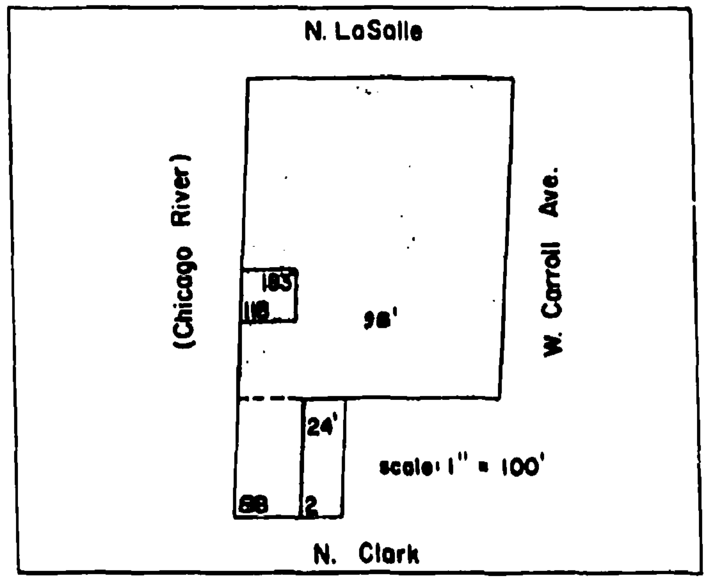
c. Data Inputs

Address 3456 N. Damen Avenue, Chicago, Illinois

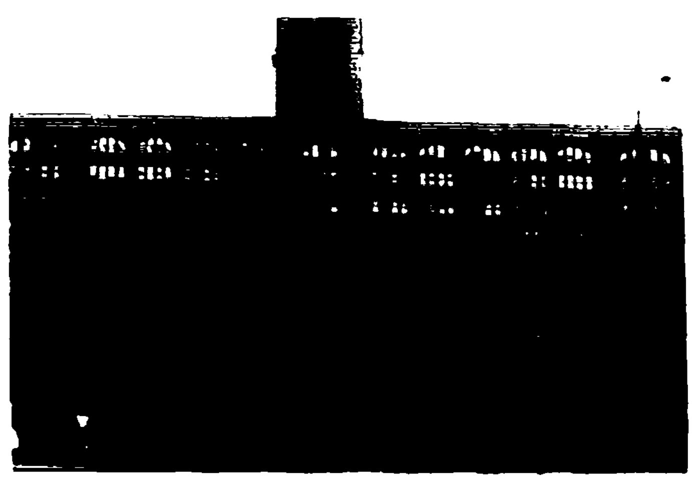
No.	Item		AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories			
2.	Height-Total Building			
3.	Length-Exterior Wall	A		
4.		B		
5.	Basement Exposure	A		
6.		B		
7.		C		
8.		D		
9.	PSF-Roof			
10.	Basement Floor			
11.	First Floor		ACCESS DENIED	
12.	Upper Floor			
13.	Basement X_c	A	NO DATA COLLECTED	
14.		B		
15.		C		
16.		D		
17.	Walls-First X_c	A		
18.		B		
19.		C		
20.		D		
21.	-Upper X_c	A		
22.		B		
23.		C		
24.		D		
25.	-Upper X	A		
26.	(if a change)	B		
27.		C		
28.		D		
29.	Partitions-Basement	A		
30.		B		
31.		C		
32.		D		
33.	-First	A		
34.		B		
35.		C		
36.		D		
37.	-Upper	A		
38.		B		
39.		C		
40.		D		
41.	% Apertures-Basement	A		
42.		B		
43.		C		
44.		D		
45.	-First	A		
46.		B		
47.		C		
48.		D		
49.	-Upper	A		
50.		B		
51.		C		
52.		D		
53.	-Upper	A		
54.	(if a change)	B		
55.		C		
56.		D		

25. Address: 320 N. Clark Avenue, Chicago, Ill.

a. Plan View



b. Photograph



c. Data Inputs

Address 320 N. Clark Ave., Chicago, Illinois

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		10	8 B
2.	Height-Total Building		125	98
3.	Length-Exterior Wall	A	185	185
4.		B	303	225
5.	Basement Exposure	A	-	0
6.		B	-	5
7.		C	-	0
8.		D	-	3
9.	PSF-Roof		50	100
10.	Basement Floor		-	-
11.	First Floor		-	150
12.	Upper Floor		80	140
13.	Basement X_e	A	-	130
14.		B	-	160
15.		C	-	140
16.		D	-	100
17.	Walls-First X_e	A	150	130
18.		B	110	160
19.		C	110	140
20.		D	110	100
21.	-Upper X_e	A	110	130
22.		B	110	160
23.		C	110	140
24.		D	110	100
25.	-Upper X_e	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	-	0
30.		B	-	0
31.		C	-	0
32.		D	-	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0 60*
38.		B	0	0 60*
39.		C	0	0 60*
40.		D	0	0 60*
41.	% Apertures-Basement	A	-	0
42.		B	-	20
43.		C	-	0
44.		D	-	0
45.	-First	A	0	0
46.		B	40	40
47.		C	10	0
48.		D	20	30
49.	-Upper	A	40	20
50.		B	40	40
51.		C	40	40
52.		D	40	40
53.	-Upper	A	-	3rd 30
54.	(if a change)	B	-	3rd 40
55.		C	-	3rd 40
56.		D	-	3rd 30

* Change to 60 - 3rd up.

d. Results of PF Computations

Detector Location: Floor 5, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1,	100	.010	0	.010
Phase 2.	No Change			
RTI FOSDIC (No X_1)	110	.009	0	.009
FOSDIC (X_1)	500	.002	0	.002
EM	770	.0013	0	.0013

e. Analysis of Differences

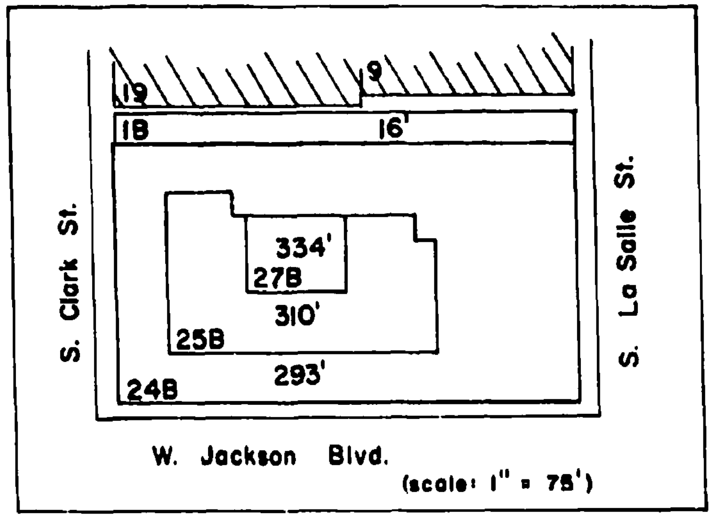
(1) Input Data - A large, deep river adjacent to the building was counted in Phase 1 as a plane of contamination, but should have been considered as a cleared strip. One story too many was also counted. The AE roof weight was 50 psf lighter and upper floor weights were 60 psf lighter than RTI data. AE walls were 20 psf lighter on 1 side, 50 psf lighter on another, 30 psf on another, and 10 psf greater on the fourth.

RTI had 60 psf interior partitions on all four sides, and the AE had 20 percent more apertures on 1 side.

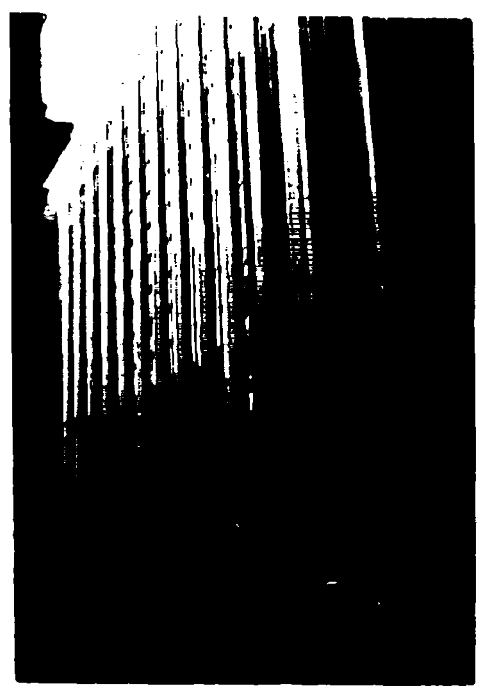
(2) Procedures - The primary differences between the Phase 1 PF and the EM PF other than the inputs were the sill correction, treatment of the river as a cleared strip, and extremely heavy (140 psf) floors which shield a large fraction of the radiation.

26. Address: 111 W. Jackson Blvd., Chicago, Ill.

a. Plan View



b. Photograph



c. Data Inputs

Address 111 W. Jackson Blvd., Chicago, Illinois

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		27 B	27 B
2.	Height-Total Building		333	334
3.	Length-Exterior Wall	A	215	215
4.		B	121	134
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		60	50
10.	Basement Floor		-	-
11.	First Floor		70	80
12.	Upper Floor		70	80
13.	Basement X_c	A	110	120
14.		B	130	120
15.		C	350	120
16.		D	110	120
17.	Walls-First X_c	A	520	520
18.		B	470	450
19.		C	280	180
20.		D	470	450
21.	-Upper X_c	A	520	120
22.		B	470	120
23.		C	470	120
24.		D	470	120
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	90	90
46.		B	90	90
47.		C	0	0
48.		D	90	90
49.	-Upper	A	90	70
50.		B	90	70
51.		C	90	70
52.		D	90	70
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 9, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	71	.014	0	.014
Phase 2.	120	.0085	0	.0085
RTI FOSDIC (No X_i)	83	.012	0	.012
EM	550	.0018	0	.0018

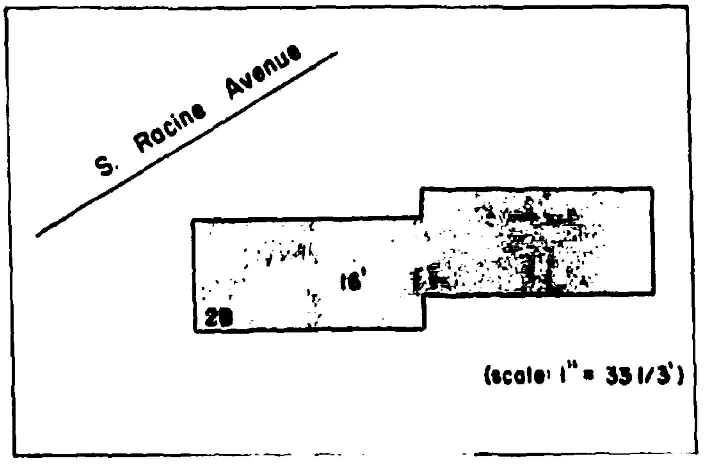
e. Analysis of Differences

(1) Input Data - The average upper X_e estimated by the AE in Phase 1 was greater than 480 psf and the percent of apertures was 90 percent for all walls. The RTI data were 120 psf for X_e and 70 percent apertures. The RTI exterior wall B dimension was 13 feet longer than the AE dimension.

(2) Procedures - The major difference in PF was due to the Computer Program's determining that the first plane on one side was a neighboring roof. Since the detector was above the second plane, the computer calculated a contribution from the second plane. A correction for this was made by the AE in Phase 2. This was another building with a lot of mutual shielding.

27. Address: 10875-81 S. Racine Avenue, Chicago, Ill.

a. Plan View



b. Photograph

c. Data Inputs

Address 10875-81 S. Racine Ave., Chicago, Illinois

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		02 B	2 B
2.	Height-Total Building		018	16
3.	Length-Exterior Wall	A	128	88
4.		B	022	22
5.	Basement Exposure	A	2	2
6.		B	2	3
7.		C	2	3
8.		D	2	3
9.	PSF-Roof		60	10
10.	Basement Floor		-	-
11.	First Floor		80	60
12.	Upper Floor		80	60
13.	Basement X_c	A	120	100
14.		B	120	100
15.		C	120	100
16.		D	120	100
17.	Walls-First X_c	A	80	70
18.		B	80	70
19.		C	80	70
20.		D	80	70
21.	-Upper X_c	A	80	70
22.		B	80	70
23.		C	80	70
24.		D	80	70
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	30
30.		B	0	30
31.		C	0	30
32.		D	0	30
33.	-First	A	0	40
34.		B	0	40
35.		C	0	40
36.		D	0	40
37.	-Upper	A	0	40
38.		B	0	40
39.		C	0	40
40.		D	0	40
41.	% Apertures-Basement	A	10	10
42.		B	0	0
43.		C	10	40
44.		D	0	0
45.	-First	A	50	30
46.		B	50	0
47.		C	50	30
48.		D	50	0
49.	-Upper	A	50	20
50.		B	50	0
51.		C	50	30
52.		D	50	0
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	71	.013	.001	.014
Phase 2.	56	.012	.006	.018
RTI FOSDIC (No X_i)	33	.022	.008	.030
FOSDIC (X_i)	53	.011	.008	.019
EM	71	.011	.0031	.0141

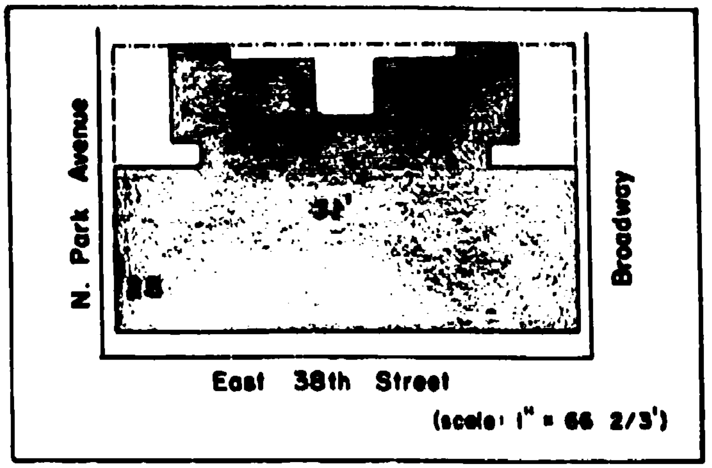
e. Analysis of Differences

(1) Input Data - A 60 psf roof and 80 psf floors were listed by the AE in Phase 1 whereas RTI data were 10 psf and 60 psf, respectively. The AE adjusted his values in Phase 2 by using the same values as RTI. The AE basement walls were also 20 psf higher than the RTI estimate. Interior partitions of 30 psf were omitted by the AE; the AE exterior wall A dimension was 40 feet too great; and the apertures were estimated as being 30 percent less than RTI on one side.

(2) Procedures - Basement exposure procedural difference whereby too much direct contribution is calculated by the computer occurred again.

28. Address: 604 E. 38th Street, Indianapolis, Ind.

a. Plan View



b. Photograph

c. Data Inputs

Address 604 E. 38th Street, Indianapolis, Indiana

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		2 B	2 B
2.	Height-Total Building		024	31
3.	Length-Exterior Wall	A	225	175
4.		B	135	115
5.	Basement Exposure	A	5	7
6.		B	5	7
7.		C	5	7
8.		D	5	7
9.	PSF-Roof		60	10
10.	Basement Floor		-	-
11.	First Floor		60	20
12.	Upper Floor		60	20
13.	Basement X_c	A	150	160
14.		B	150	130
15.		C	150	190
16.		D	150	130
17.	Walls-First X_c	A	80	140
18.		B	80	130
19.		C	80	100
20.		D	80	130
21.	-Upper X_c	A	80	140
22.		B	80	130
23.		C	80	100
24.		D	80	130
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	110
30.		B	0	0
31.		C	0	110
32.		D	0	0
33.	-First	A	60	110
34.		B	60	0
35.		C	60	110
36.		D	60	0
37.	-Upper	A	60	110
38.		B	60	0
39.		C	60	110
40.		D	60	0
41.	% Apertures-Basement	A	20	30
42.		B	20	30
43.		C	20	10
44.		D	20	30
45.	-First	A	40	30
46.		B	40	20
47.		C	40	40
48.		D	40	20
49.	-Upper	A	40	30
50.		B	40	20
51.		C	40	10
52.		D	40	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 0, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	53	.016	.003	.019
Phase 2.	104	.00661	.003	.00961
RTI FOSDIC (X_i and No X_i)	Both cases had PF less than 20			
EM	185	.0023	.0031	.0054

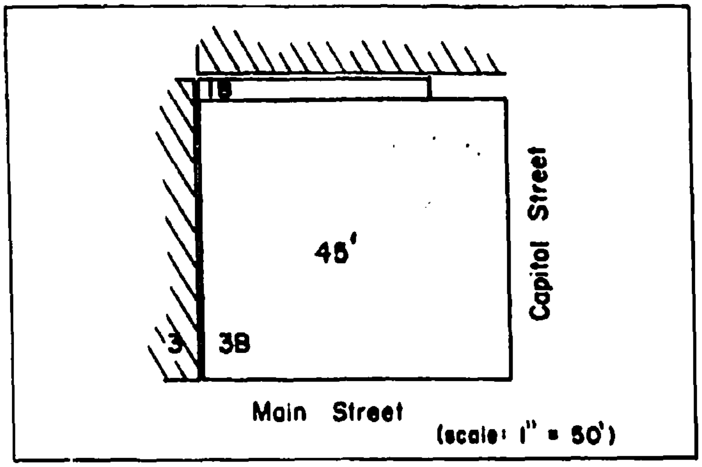
e. Analysis of Differences

(1) Input Data - Concrete floors were only in the corridors. Therefore, the assumption by the AE that the entire floor was concrete accounted for a large difference in estimated floor psf's (10-60 psf). Substantial partitions of 110 psf were not counted in Phase 1 but an adjustment was made for them in Phase 2.

(2) Procedures - There was basement exposure of 7 feet but the detector was still below grade. Major contribution from direct radiation calculated in Phase 1 for an exposed basement is eliminated by the EM method.

29. Address: 619 Main Street, Houston, Texas

a. Plan View



b. Photograph

c. Data Inputs

Address 619 Main St., Houston, Texas

			AE-FOSDIC	RT1-FOSDIC
1.	No. of Stories		03 B	3 B
2.	Height-Total Building		042	45
3.	Length-Exterior Wall	A	100	100
4.		B	100	100
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		80	50
10.	Basement Floor		-	-
11.	First Floor		90	30
12.	Upper Floor		70	30
13.	Basement X_c	A	180	160
14.		B	340	60
15.		C	180	90
16.		D	180	160
17.	Walls-First X_c	A	150	190
18.		B	300	100
19.		C	150	100
20.		D	150	190
21.	-Upper X_c	A	130	80
22.		B	300	100
23.		C	130	100
24.		D	130	80
25.	-Upper X	A	-	3rd 60
26.	(if a change)	B	-	3rd 100
27.		C	-	3rd 100
28.		D	-	3rd 60
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	90	50
46.		B	0	0
47.		C	10	0
48.		D	90	40
49.	-Upper	A	20	40
50		B	0	0
51.		C	0	10
52.		D	60	40
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	0
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 2, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	63	.010	.006	.016
Phase 2.	No data other than D side A_p from 60% to 20%			
RTI FOSDIC (No X_1)	20	.018	.032	.050
EM	26	.0145	.0235	.0380

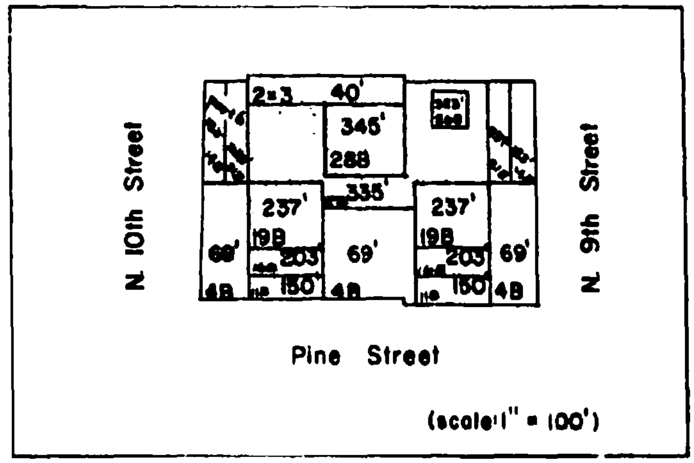
e. Analysis of Differences

(1) Input Data - AE Phase 1 data indicated heavy floors over the entire building, whereas one-half had concrete and the other half had wooden floors. AE estimates for exterior wall weights were 50 psf higher than RTI on 2 sides, 30 psf higher on another, and 200 psf higher on the fourth.

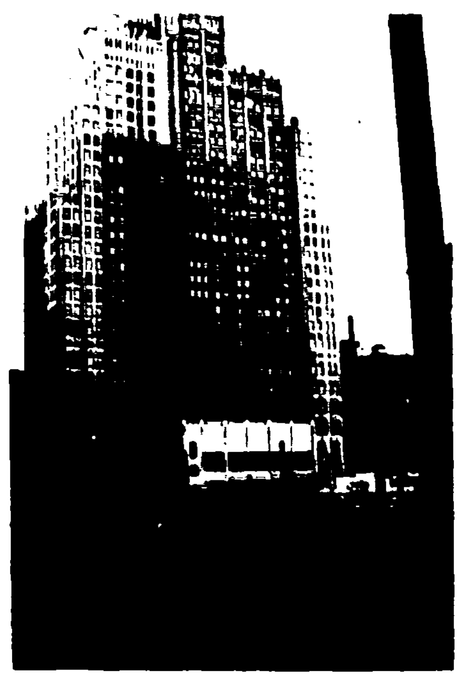
(2) Procedures - Procedural differences of importance in this building were only the sill correction and usual EM use of azimuthal sectors to handle varying planes and wall weights.

30. **Address:** 1010 Pine Street, St. Louis, Mo.

a. Plan View



b. Photograph



c. Data Inputs

Address 1010 Pine St., St. Louis, Mo.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		21 B	21 B
2.	Height-Total Building		247	248
3.	Length-Exterior Wall	A	030	32
4.		B	070	67
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		70	120
10.	Basement Floor		170	90
11.	First Floor		150	90
12.	Upper Floor		100	90
13.	Basement X_c	A	450	450
14.		B	450	450
15.		C	450	450
16.		D	450	450
17.	Walls-First X_c	A	280	160
18.		B	280	160
19.		C	280	160
20.		D	280	160
21.	-Upper X_c	A	280	160
22.		B	280	160
23.		C	280	160
24.		D	280	160
25.	-Upper X	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	60	0
46.		B	60	60
47.		C	30	60
48.		D	60	0
49.	-Upper	A	50	0
50.		B	50	40
51.		C	50	40
52.		D	50	0
53.	-Upper	A	-	5th 30
54.	(if a change)	B	-	-
55.		C	-	8th 30
56.		D	-	4th 10

d. Results of PF Computations

Detector Location: Floor 13, Part 6 of 9

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	50	.020	0	.020
Phase 2.	No Change - AE Denied Access			
RTI FOSDIC (No X_i)	83	.012	0	.012
EM	127	.0070	.0009	.0079

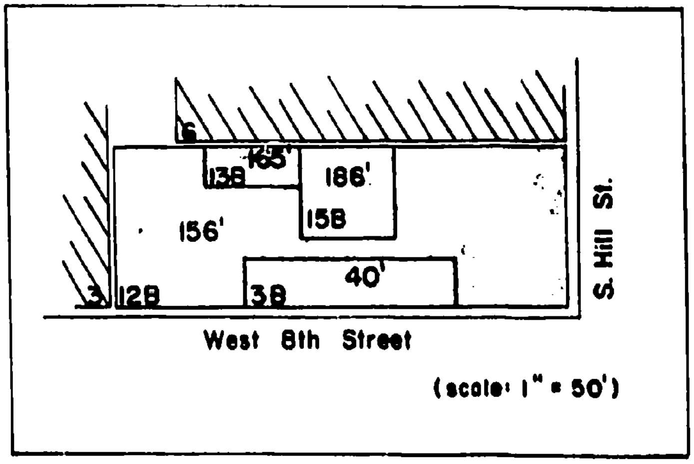
e. Analysis of Differences

(1) Input Data - AE Phase 1 data indicated 20 percent more apertures on 2 sides, 10 percent on a third, and 40 percent on the fourth. The AE Phase 1 X_e was also 120 psf higher than the RTI value.

(2) Procedures - Sill and floor slab shielding of direct radiation plus the difference in procedures involved with dividing the building into parts were major procedural differences accounting for the increase in the EM PF over the RTI FOSDIC PF.

31. Address: 403 West 8th Street, Los Angeles, Cal.

a. Plan View



b. Photograph

c. Data Inputs

Address 403 W. 8th St., Los Angeles, California

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		12 B	12 B
2.	Height-Total Building		180	156
3.	Length-Exterior Wall	A	180	160
4.		B	060	45
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	0	0
8.		D	0	0
9.	PSF-Roof		30	50
10.	Basement Floor		-	-
11.	First Floor		100	50
12.	Upper Floor		50	50
13.	Basement X_c	A	200	150
14.		B	200	150
15.		C	200	150
16.		D	200	150
17.	Walls-First X_c	A	120	140
18.		B	120	100
19.		C	120	100
20.		D	120	140
21.	-Upper X_c	A	120	140
22.		B	120	100
23.		C	120	100
24.		D	120	140
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	30
30.		B	0	30
31.		C	0	30
32.		D	0	30
33.	-First	A	0	0
34.		B	0	30
35.		C	0	30
36.		D	0	30
37.	-Upper	A	0	20
38.		B	0	20
39.		C	0	20
40.		D	0	60
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	0	0
44.		D	0	0
45.	-First	A	80	90
46.		B	0	0
47.		C	0	0
48.		D	80	90
49.	-Upper	A	50	30
50.		B	0	0
51.		C	0	0
52.		D	50	30
53.	-Upper	A	-	-
54.	(if a change)	B	4th 40	3rd 30
55.		C	9th 40	7th 10
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 4, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	77	.013	0	.013
Phase 2.	170	.006	0	.006
RTI FOSDIC (No X_i)	110	.009	0	.009
FOSDIC (X_i)	200	.005	0	.005
EM	1250	.0008	0	.0008

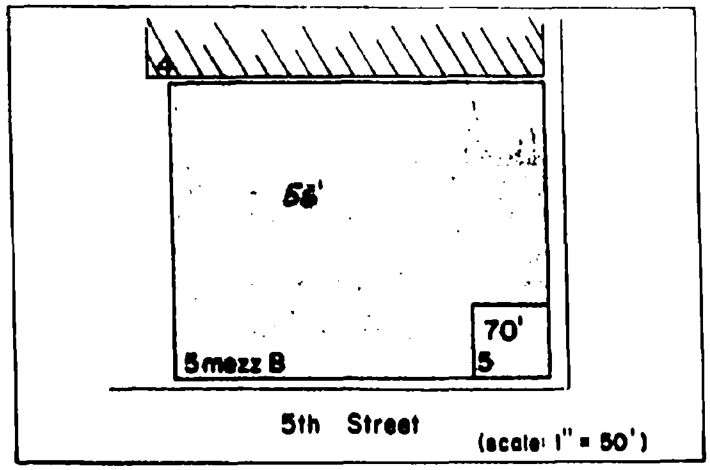
e. Analysis of Differences

(1) Input Data - Partitions of 20 to 60 psf were omitted in Phase 1 (added in Phase 2) and 20 percent more apertures were counted on 2 sides by the AE.

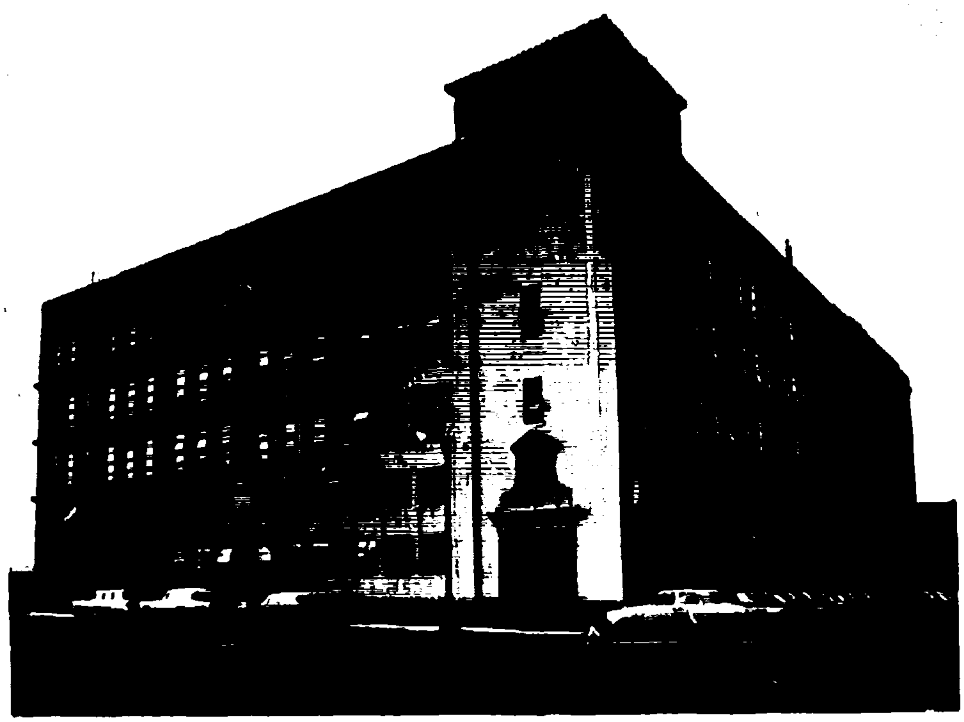
(2) Procedures - The building had a "U" shape which, along with narrow contaminated planes, helped to shield against most of the direct radiation and a part of the scattered radiation in the EM method. The building also had heavy walls below sill level and 50 psf floors which led to a higher RTI EM PF because of the shielding of direct radiation.

32. Address: 650 5th Street, San Francisco, Cal.

a. Plan View



b. Photograph



c. Data Inputs

Address 650 5th St., San Francisco, California

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		05 B	5 B
2.	Height-Total Building		066	56
3.	Length-Exterior Wall	A	130	130
4.		B	100	100
5.	Basement Exposure	A	3	3
6.		B	3	3
7.		C	3	3
8.		D	3	3
9.	PSF-Roof		40	70
10.	Basement Floor		-	-
11.	First Floor		100	100
12.	Upper Floor		100	100
13.	Basement X_c	A	150	150
14.		B	150	150
15.		C	150	150
16.		D	150	150
17.	Walls-First X_c	A	100	100
18.		B	100	100
19.		C	100	100
20.		D	100	100
21.	-Upper X_c	A	80	100
22.		B	80	100
23.		C	80	100
24.		D	80	100
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	0
34.		B	0	0
35.		C	0	0
36.		D	0	0
37.	-Upper	A	0	0
38.		B	0	0
39.		C	0	0
40.		D	0	0
41.	% Apertures-Basement	A	30	10
42.		B	0	0
43.		C	0	0
44.		D	30	30
45.	-First	A	40	40
46.		B	0	0
47.		C	0	0
48.		D	40	30
49.	-Upper	A	40	30
50.		B	10	10
51.		C	0	0
52.		D	40	20
53.	-Upper	A	-	-
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

d. Results of PF Computations

Detector Location: Floor 2, Part 1 of 1

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	42	024	0	.024
Phase 2.	No Change			
RTI FOSDIC (No X_i)	50	.020	0	.020
EM	100	.010	0	.010

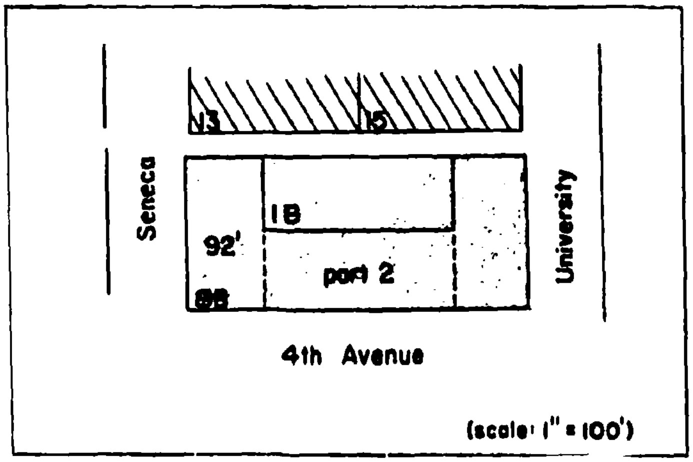
e. Analysis of Differences

(1) Input Data - A number of obvious errors were made by the AE in contaminated plane heights and widths and the X_e was 20 psi less in Phase 1 than on the RTI FOSDIC. Apertures were also estimated by the AE as 10 percent more on one side and 20 percent more on another. These errors are nearly compensating.

(2) Procedures - Sill heights and a major partition parallel to one wall and on only one story accounted for the major change in PF using the EM.

33. Address: 1215 4th Avenue, Seattle, Wash.

a. Plan View



b. Photograph

c. Data Inputs

Address 1215 4th Ave., Seattle, Wash.

			AE-FOSDIC	RTI-FOSDIC
1.	No. of Stories		08 B	8 B
2.	Height-Total Building		080	92
3.	Length-Exterior Wall	A	132	133
4.		B	100	104
5.	Basement Exposure	A	0	0
6.		B	0	0
7.		C	7	4
8.		D	0	0
9.	PSF-Roof		80	50
10.	Basement Floor		-	-
11.	First Floor		40	40
12.	Upper Floor		40	40
13.	Basement X_c	A	180	140
14.		B	180	140
15.		C	180	140
16.		D	180	140
17.	Walls-First X_c	A	150	140
18.		B	150	100
19.		C	150	140
20.		D	150	70
21.	-Upper X_c	A	150	140
22.		B	150	100
23.		C	150	140
24.		D	150	100
25.	-Upper X_c	A	-	-
26.	(if a change)	B	-	-
27.		C	-	-
28.		D	-	-
29.	Partitions-Basement	A	0	0
30.		B	0	0
31.		C	0	0
32.		D	0	0
33.	-First	A	0	30
34.		B	0	30
35.		C	0	30
36.		D	0	30
37.	-Upper	A	0	0 20*
38.		B	0	30 20*
39.		C	0	30 20*
40.		D	0	30 20*
41.	% Apertures-Basement	A	0	0
42.		B	0	0
43.		C	20	20
44.		D	0	0
45.	-First	A	0	0
46.		B	0	0
47.		C	20	30
48.		D	0	0
49.	-Upper	A	40	50
50.		B	0	0
51.		C	30	30
52.		D	0	0
53.	-Upper	A	-	3rd 40
54.	(if a change)	B	-	-
55.		C	-	-
56.		D	-	-

* Change to 20 - 3rd up.

d. Results of PF Computations

Detector Location: Floor 6, Part 2 of 3

	PF	Reduction Factors		
		Ground	Roof	Total
AE Phase 1.	71	.010	.004	.014
Phase 2.	No Change			
RTI FOSDIC (No X_i)	71	.006	.008	.014
FOSDIC (X_i)	83	.004	.008	.012
EM	189	.0017	.0036	.0053

e. Analysis of Differences

(1) Input Data - The AE Phase 1 X_e was 10 psf higher on 2 sides and 50 psf higher on the other two in Phase 1 data compared to RTI. Interior partitions of 20 psf were not counted and the roof was estimated as 30 psf higher by the AE in Phase 1. These differences were compensating so that the AE Phase 1 and RTI FOSDIC (No X_i) PF's were the same even though the respective ground and roof reduction factors were different.

(2) Procedures - This building was another example of considerable shielding of direct and skyshine radiation components by the floor slab and adjacent buildings which raised the EM PF.

II. STATISTICAL FORMULAS

The input data (each Sub-section c. of I.B.) and computational results (each Sub-section d. of I.B.) were compared statistically and reported in Tables IV and V, respectively, of Chapter 4.

In comparing any two data collection or PF computational methods, the observed difference for a sample building will be designated as d_{ijk}. The subscript "i" refers to the region, "j" refers to the particular collapsed stratum within the region, and "k" to the building within the collapsed stratum. In order to provide a basis for estimating standard errors, collapsed strata were formed by combining adjacent original strata.*

The statistical formulas are simplified by setting:

$Y_{ijk} = C_i W_{ijk} d_{ijk}$ and

$X_{ijk} = C_i W_{ijk}$

where:

Y_{ijk} is the weighted observed difference.

C_i is the number of clusters that each sample cluster represents in the ith region.

W_{ijk} is the proportionate number of buildings with shelter in at least PF Categories 2, 3, or 4 in the kth sample cluster of the jth collapsed stratum in the ith region.

X_{ijk} can be regarded as the inverse of the building selection probability.

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* For a general discussion of the use of collapsed strata for estimating standard errors see Reference 1.

An average difference, $\bar{d}$ is then found from:

$$\bar{d} = \frac{\sum_i \sum_j \sum_k Y_{ijk}}{\sum_i \sum_j \sum_k X_{ijk}}$$

The above estimator is of the ratio type. Its variance can be approximated by making use of a Taylor series expansion and substituting sample values where needed. The square of the standard error of an average difference is thus estimated by:

$$s_{\bar{d}}^2 = \frac{\sum_i \sum_j (Y_{ij1} - Y_{ij2})^2 + \bar{d}^2 \sum_i \sum_j (X_{ij1} - X_{ij2})^2 - 2\bar{d} \sum_i \sum_j (Y_{ij1} - Y_{ij2})(X_{ij1} - X_{ij2})}{\left[\sum_i \sum_j \sum_k X_{ijk}\right]^2}$$

All summations are carried out only over collapsed strata in which $k = 1, 2$. There are thirteen such strata with one degree of freedom within each stratum.

Table I-I gives the W_{ijk} and $C_i \; W_{ijk}$ values used.

The standard error of the average difference, $s_{\bar{d}}$, is an estimate of a measure of the variability expected from samples of the size and type used in the survey. The observed average difference divided by the observed standard error of the average difference provides a statistic for testing the significance of the observed average difference. In this survey, this statistic is approximately distributed as the "t" distribution with either twelve or thirteen degrees of freedom.

The term degrees of freedom is a technical expression referring to a parameter of the "t" distribution which was used to determine statistical significance. In this survey, each collapsed stratum with two observations contributed one degree of freedom to the computation of the observed "t" value. The total number of degrees of freedom is simply the sum over the set of collapsed strata.

TABLE I-I

33 Building Sample Statistical Characteristics

Region	C_i	Collapsed Stratum (j)	Bldg. Within Collapsed Stratum (k)	Bldg. No.	W_{ijk}	C_iW_{ijk}
1	1638	1	1	17	2.0000	3276.0000
			2	1	2.0000	3276.0000
		2	1	15	3.0000	4914.0000
			2	16	1.0000	1638.0000
		3	1	8	0.6250	1023.7500
			2	9	1.1429	1872.0702
		4	1	10	0.2000	327.6000
			2	11	6.0000	9828.0000
		5	1	12	0.2061	337.5918
			2	13	1.0000	1638.0000
		6	1	14	3.5000	5733.0000
			2	6	1.0000	1638.0000
		7	1	7	5.0000	8190.0000
			2	3	0.1667	273.0546
		8	1	4	0.1250	204.7500
			2	5	1.0000	1638.0000
		9	1	2	0.1429	234.0702
2	1485	1	1	22	1.0000	1485.0000
			2	18	0.2778	412.5330
		2	1	19	0.0945	140.3325
			2	21	0.0588	87.3180
		3	1	20	3.0000	4455.0000
3	655	1	1	23	1.0000	655.0000
4,6	2054*	1	1	28	3.0000	6162.0000
			2	25	.3333	684.5982
		2	1	26	.1667	342.4018
			2	27	3.0000	6162.0000
		3	1	30	.0596	122.4184
5	1091	1	1	29	4.0000	4364.0000
7	1076	1	1	31	0.5000	538.0000
			2	32	2.0000	2152.0000
8	838	1	1	33	0.3333	279.3054

* Adjusted for sample building not surveyed due to denial of access

REFERENCE

1. W. G. Cochran. Sampling Techniques. (Second Edition). New York: John Wiley and Sons, Inc., 1963. P. 141.

Appendix J

Construction Details of Buildings Used in Comparison of Experimental and Computed PF's

I. INTRODUCTION

Some construction details of the four buildings analyzed in Part I, Chapter 5 were reported by Edgerton, Germeshausen, and Grier, Inc. (EG&G) in References 1 and 2. This appendix presents additional data needed for the Engineering Manual computations of these buildings.

The lengths and widths reported are outside dimensions; story heights are from the top of the floor slab to the top of the next higher floor slab (or roof slab); and material weights (mass thicknesses) were derived by using minimums given in Reference 3 if weights were not reported on the building plans. Mass thicknesses derived from Reference 3 are denoted by an asterisk in Section II.

II. CONSTRUCTION DETAILS

A. Brookhaven National Laboratory Medical Research Building

Stories: One with basement

Length: 270'

Width: 200'

Story Height: Basement = 11' - 0"

First = 12' - 3"

First Story Floor Weight:	5" reinforced concrete	62.5 psf	
	1½" cement fill and finish	12.5 psf	
			75.0 psf
First Story Ceiling Weight:	Suspended metal lath and plaster ceiling covered with acoustic tile		15.0 psf*
Roof Weight:	Built up roofing, 2" insulation, 2½" poured gypsum concrete fill, gypsum form board and open web steel joist		36.0 psf*
Basement Wall Weight:	7" reinforced concrete	87.5 psf	
	4" brick	38.0 psf	
			125.5 psf
First Story Wall Weight:	3/4" plaster	5.0 psf	
	6" hollow concrete block	40.0 psf	
	4" brick	38.0 psf	
			83.0 psf

Basement Exposure: Varied on the two test sides from 2' to 11'

Partitions: (a) Basement: About 400 12"x12" columns from floor to ceiling with a number of 8"x8" cross joists 100.0 psf

*Estimated from data in Reference 3.

(b) First Floor (divided into about 150 rooms)

4" hollow concrete block	30.0 psf
or 8" hollow concrete block	55.0 psf
or 12" reinforced concrete	150.0 psf

Note: Some directions did not have any interior partitions and some had multiple partitions.

B. The Laboratory of Nuclear Medicine and Radiation Biology of the University of California in Los Angeles

Stories: Two with basement

Length: 180'

Width: 59'

Story Height: Basement 13' - 9"

First & Upper 12' - 9"

Floor and Roof Weight: 9" of reinforced concrete	112.5 psf
Basement Wall Weight: 8" of reinforced concrete	100.0 psf
First Story Wall Weight: Because the first story wall is a masonry screen, the smeared effective weight is	25.0 psf

Basement Exposure: Rear 3'

Front 4'

Partitions: Basement and First Floor - 2" metal frame, metal lath with 3/4" plaster on each side	20.0 psf*

C. The Communications Center of the Los Angeles Police Department Building

Stories: One and eight

Length: 154' (for ground contribution)

Width: 154' (for ground contribution)

*Estimated from data in Reference 3.

Story Height:	First = 15' - 3"		
	Upper = 9' - 9"		
Second Story Floor Weight:	6" min. reinforced concrete		75.0 psf
Roof Weight:	6" min. reinforced concrete		75.0 psf
First Story Wall Weight:	10½" reinforced concrete	130.0 psf	
	1½" tile and cement	15.0 psf	
			145.0 psf

Partitions: Mostly light partitions (10 psf); however, there was a 14" concrete partition in part of the building

D. A Typical Classroom at North Hollywood High School

Stories: Two without basement

Length: 98' - 6"

Width: 71' - 0"

Story Height:	First = 14' - 0"		
	Second = 14' - 0"		
Floor Weight:	3" reinforced concrete	37.5 psf	
	(4" concrete slab in corridor)		
	Suspended metal lath and 3/4" plaster ceiling	15.0 psf	
			52.5 psf
Roof Weight:	3" reinforced concrete	37.5 psf	
	Built up roofing	5.5 psf*	
			43.0 psf
Wall Weight:	12" reinforced concrete		150.0 psf
Partition Weight:	Metal lath with plaster on both sides		20.0 psf

*Estimated from data in Reference 3.

REFERENCES

1. H. Borella, Z. Burson and J. Janovitch. Evaluation of the Fallout Protection Afforded by Brookhaven National Laboratory Medical Research Center. USAEC Report CEX-60.1. Santa Barbara, California: Edgerton, Germeshausen and Grier, Inc., October 1961.*

2. Z. G. Burson. Experimental Evaluation of the Fallout-Radiation Protection Provided by Selected Structures in the Los Angeles Area. USAEC Report CEX-61.4.* Las Vegas, Nevada: Edgerton, Germeshausen and Grier, Inc., February 1963.

3. Ernest W. Cannon. Building Materials as Commonly Used in Existing Urban Buildings in the United States. Project Civil. Richmond, California: Institute of Engineering Research, University of California, 8 January 1958.

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* Available from Office of Technical Services, Department of Commerce, Washington 25, D. C.

Appendix K

Potable Water Survey-Field Data

I. INTRODUCTION

This appendix presents the potable water field data obtained by RTI during the survey of the statistical sample of 33 NFSS structures. An outline of data collection procedures and an analysis of field results are presented in Part I, Chapter 8. The data presented in this appendix were previously reported to OCD as part of Research Memorandum RM 81-6 (Reference 1).

The potable water data were collected in the following categories:

A. Fire Control Tank
B. Sprinkler System
C. Hot Water Heater
D. Supply Pipe
E. Holding Tank
F. Water Closet Flush Tanks
G. Air Conditioner (non-treated)
H. Heating Tank (non-treated)
I. Indoor Swimming Pool
J. Miscellaneous (all containers not in A.-I. above)

It should be noted that some of the water contained in the build'ngs was not potable because of treatment with a rust inhibitor. Also, containers holding insignificant water, such as small pipes, were ignored.

II. DATA

1. Boston, Mass. 30-32 N. Bennet Street Recreation Facility

1 Hot Water Heater @ 5,700 gal.		5,700
1 Water Closet Flush Tank @ 4 gal.		4
1 Heating Tank (non-treated) @ 147 gal.		147
1 Misc. @ 165 gal.		165
	Total	6,016 gals.

2. Newark, N. J. 73-77 17th Avenue Rev. Wm. P. Hayes Apts.

1 Hot Water Heater @ 2,200 gal.		2,200
144 Water Closet Flush Tank @ 4 gal.		576
	Total	2,776 gals.

3. Bronx, N. Y. C. 650 Grand Concourse Cardinal Hayes H. S.

1 Hot Water Heater @ 215 gal.		215
3 Misc. Hot Water Tank @ 940 gal.		2,820
	Total	3,035 gals.

4. Bronx, N. Y. C. 1235 Grand Concourse Apartments

1 Hot Water Heater @ 2,800 gal.		2,800
	Total	2,800 gals.

5. Bronx, N. Y. C. 81 W. 182nd Street Apartments

Total 0 gals.

6. Brooklyn, N. Y. C. 5101-23 13th Avenue Apts.-Offices

Total 0 gals.

7. Brooklyn, N. Y. C. 485 Bedford Avenue Apartments

Total 0 gals.

8. Manhattan, N. Y. C. 304 Broadway Fordham University

1 Hot Water Heater @ 120 gal.		120
1 Holding Tank @ 10,000 gal.		10,000
	Total	10,120 gals.

9. Manhattan, N. Y. C. 435 Hudson Street Warehouse

1 Fire Control Tank @ 20,000 gal.		20,000
1 Holding Tank & Standpipe @ 15,000 gal.		15,000
1 Misc. Pressure Tank @ 9,000 gal.		9,000
	Total	44,000 gals.

10. Manhattan, N. Y. C. 300 Park Avenue Colgate Palmolive-Offices

2 Fire Control Tank @ 3,500 gal.		7,000
1 Hot Water Heater @ 1,500 gal.		1,500
1 Holding Tank @ 5,500 gal.		5,500
2 Misc. @ 11,500 gal.		23,000
	Total	37,000 gals.

11. Manhattan, N. Y. C. 362 W. 52nd Street Apartments

26 Water Closet Flush Tank @ 9 gal.		234
1 Misc. on top (Pressure) @ 2,000 gal.		2,000
	Total	2,234 gals.

12. Manhattan, N. Y. C. 327 W. 75th Street Apartments

1 Fire Control Tank @ 3,500 gal.		3,500
2 Hot Water Heater (holding) @ 740 gal.		1,480
1 Holding Tank @ 11,500 gal.		11,500
	Total	16,480 gals.

13. Manhattan, N. Y. C. 47-49 W. 129th Street Apartments

Total 0 gals.

14. Manhattan, N. Y. C. 360 Cabrini Blvd. Apartments

1 Misc. Pressure Tank @ 5,000 gal.		5,000
	Total	5,000 gals.

15. Queens, N. Y. C. 4107 10th Street Queen's Bridge Housing-Apts.

¼ Hot Water Heater @ 550 gal.		140
	Total	140 gals.

16. Queens, N. Y. C. 14415 Sanford Avenue Coral Garden Apts.

1 Holding Tank @ 3,500 gal. -		3,500
	Total	3,500 gals.

17. Rochester, N. Y. 37-49 South Avenue Simonds Press-Printing & Stores

1 Sprinkler System @ 629 gal. -		629
1 Hot Water Heater @ 30 gal. -		30
6 Water Closet Flush Tank @ 4 gal. - - - - - - - - - - - - - - - - -		24
	Total	683 gals.

18. Washington, D. C. 2700 Connecticut Avenue Hampton House Apts.

3 Hot Water Heater @ 80 gal. -		240
1 Misc. Hot Water Holding @ 1,695 gal. - - - - - - - - - - - - - - -		1,695
	Total	1,935 gals.

19. Washington, D. C. 18th and C Streets Dept. of Interior-Offices

1 Fire Control Tank filled to 5' @ 7,400 gal. - - - - - - - - - - -		7,400
3 Hot Water Heater @ 1,040 gal. - - - - - - - - - - - - - - - - - -		3,120
2 Holding Tank filled to 5' @ 7,400 gal. - - - - - - - - - - - - -		14,800
1 Air Conditioner (treated) @ 31,600 gal. - - - - - - - - - - - - -		31,600*
1 Misc. @ 1,870 gal. -		1,870
	Total	27,190 gals.

20. Louisville, Ky. 1011 W. Market Street Apartments

6 Water Closet Flush Tank @ 4 gal. - - - - - - - - - - - - - - - - -		24
	Total	24 gals.

21. Cleveland, Ohio 917 Euclid Avenue Union Commerce-Offices

1 Hot Water Heater @ 400 gal. -		400
2 Hot Water Heater @ 1,200 gal. - - - - - - - - - - - - - - - - - - -		2,400
6 Supply Pipe for fire control @ 64 gal. - - - - - - - - - - - - - -		384
1 Misc. Pressure Tank @ 3,000 gal. - - - - - - - - - - - - - - - - - -		3,000
2 Misc. Pressure Tank @ 5,000 gal. - - - - - - - - - - - - - - - - -		10,000
	Total	16,184 gals.

* Treated with Borgana-600 (not potable) -- only partially filled in summer.

22. Philadelphia, Pa. 257 S. 16th Street Sprucemont Apts.

3" Copper Supply Pipe @ 74 gal.	74
1 Fire Control Tank @ 4,400 gal.	4,400
55 Water Closet Flush Tank @ 4 gal.	220
1 Misc. Pilot Tank @ 500 gal.	500
Total	5,194 gals.

23. Memphis, Tenn. 70 West E. H. Crump Blvd. Watkins Products Co. (Manufacturing and Offices)

1 Fire Control Tank @ 7,520 gal.	7,520
1 Sprinkler System @ 2,236 gal.	2,236
1 Hot Water Heater @ 75 gal.	75
1 Misc. @ 19,830 gal.	19,830
Total	29,661 gals.

24. Chicago, Ill. 3456 N. Damen Avenue

<u>Access Denied</u>

25. Chicago, Ill. 320 N. Clark Avenue Central Office Building of Chicago

3 Hot Water Heater @ 35 gal.	105
1 Hot Water Heater @ 940 gal.	940
1 Hot Water Heater @ 235 gal.	235
1 Holding Tank @ 33,593 gal.	33,593
40 Water Closet Flush Tank @ 4 gal.	160
Total	35,033 gals.

26. Chicago, Ill. 111 W. Jackson Blvd. LaSalle-Jackson-Offices

1 Hot Water Heater @ 500 gal.	500
1 Holding Tank @ 4,700 gal.	4,700
4 Air Conditioner (treated) @ 187 gal.	748*
Total	5,200 gals.

* Not potable

27. Chicago, Ill. 10875-81 S. Racine Ave. Racine Courts-Apts.

4 Hot Water Heater @ 30 gal.		120
4 Water Closet Flush Tank @ 4 gal.		16
	Total	136 gals.

28. Indianapolis, Ind. 604 E. 38th Street Public School 66

1 Hot Water Heater @ 141 gal.		141
3 Heating Tank (non-treated) @ 300 gal.		900
	Total	1,041 gals.

29. Houston, Texas 619 Main Street Darling Shop & Others-Stores

1 Hot Water Heater @ 648 gal.		648
1 Air Conditioner (non-treated) cooling tower @ 479 gal.		479*
	Total	648 gals.

*Not covered or protected from fallout

30. St. Louis, Mo. 1010 Pine St. S. W. Bell Telephone Co. (Exchange and Offices)

2 Fire Control Tank @ 4,660 gal.		9,320
6 Hot Water Heater @ 206.2 gal.		1,237
1 Holding Tank @ 19,070 gal.		19,070
1 Holding Tank @ 10,000 gal.		10,000
1 Air Conditioner (treated) @ 12,000 gal.		12,000*
	Total	39,627 gals.

*Not potable

31. Los Angeles, Calif. 403 W. 8th Street Garfield Bldg.-Offices

1 Hot Water Heater @ 529 gal.		529
1 Holding Tank @ 1904 gal.		1,904
1 Restaurant Holding Tank @ 141 gal.		141
	Total	2,574 gals.

32. San Francisco, Calif. 650 5th Street Western Machinery Co.-Mfg.

10 Sprinkler System @ 2.3 gal. -		23
1 Hot Water Heater @ 40 gal. -		40
1 Heating Tank (non-treated) @ 4 gal. - - - - - - - - - - - - - - - - -		4
	Total	67 gals.

33. Seattle, Wash. 1215 4th Avenue Stimpson Bldg.-Offices

11 Sprinkler System @ 12 gal. -		132
1 Hot Water Heater @ 118 gal. -		118
1 Hot Water Heater @ 236 gal. -		236
	Total	486 gals.

REFERENCE

1. R. O. Lyday, Jr. Survey of Potable Water Available in a Sample of 33 Buildings. Research Memorandum RM 81-6. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 7 June 1963.

Appendix L

Evaluation of "Technical Operations, Inc.,

Model Experiment Report TO-B 62-26"

This Appendix was originally submitted to OCD as Research Memorandum RM 81-3,* except for minor editorial changes.

*W. O. Doggett (Consultant, Professor of Physics, North Carolina State of the University of North Carolina at Raleigh). Evaluation of "Technical Operations, Inc., Model Experiment Report TO-B 62-26". Research Memorandum RM 81-3. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 5 November 1962.

ABSTRACT

The Technical Operations, Inc., preliminary model data for a windowless structure with 20 psf wall and floor thicknesses (Reference 1) were compared with calculations based on the Engineering Manual. (These comparisons do not include correction factors for source anisotropy and tubing attenuation which were reported by Tech Ops (Reference 2) after the RTI analyses were completed.) It is shown that the Engineering Manual calculations underestimate the dose rate or reduction factor by the same percent (15-20 percent for wide strips and 50-55 percent for narrow strips) as the National Fallout Shelter Survey Computer Program. This difference is probably due to inherent differences in the experimental and computational models. It is recommended that penetration data such as that presented in the Engineering Manual be developed for the radiations of cobalt-60 and attenuation characteristics of steel. The increasing discrepancy for close-in narrow strips from which the direct radiation must pass through a floor to reach the detector is believed to be due in part to an inaccuracy in estimating the attenuation of direct radiation. An alternative method is suggested for approximating the combined wall and floor barrier factor. It is also shown that essentially no error is incurred in scaling up the model data. No revisions to the Computer Program are recommended on the basis of this analysis.

Appendix L

Evaluation of Technical Operations, Inc., Experiments on a Multistory Windowless Building

I. INTRODUCTION

A. The Project

One of the major tasks of OCD Project 1115A was to "evaluate new information on shielding produced by other projects." This appendix presents the RTI evaluation of a research report that could affect the calculation of building protection factors. A summary of RTI's review of shielding research is contained in Part I, Chapter 6.

B. Background

Technical Operations, Inc. of Burlington, Mass., (Tech Ops) has conducted a series of gamma-ray experiments on model buildings under contract with the Office of Civil Defense. In these reports, a preliminary comparison of the data was made with the results predicted by the Architects and Engineers Guide (Reference 3) and the National Fallout Shelter Survey Computer Program (Reference 4). It was found by Tech Ops that the functional dependence of the finite-field correction factors on the geometric parameters which characterize limited planes of contamination is essentially correct; however, the computational procedure of the Computer Program underestimates the absolute dose rate (overestimates the protection factor) that was experimentally measured.

C. Purpose

The purpose of the RTI investigation was twofold: (a) to compare the experimental data for 20 psf wall and floor mass thicknesses with calculations made according to the more precise Engineering Manual method (Reference 5); and (b) to

recommend revised procedures wherever possible. It is assumed that the reader is familiar with the Tech Ops report (Reference 1) and the Engineering Manual (Reference 5).

D. Tech Ops Experiments

The first phase of the Tech Ops program was an investigation of the effect of limited planes of contamination on the dose rate in a multistory windowless building with 20 psf wall and floor mass thicknesses (Reference 1). A six-story 36 x 48 x 72-foot high building was simulated by a model structure with a 1/12 scale factor and 1/2-inch thick (20 psf) steel walls and floors. Quarter symmetry planes of contamination were formed by closely spaced cobalt-60 point sources near the building and by the pumped source method in outer planes. Dose measurements were made in three horizontal planes above each floor at points in each plane near the corners and at the center of the building.

E. Summary of RTI Analysis

In the following sections, a detailed analysis of the data presented in Reference 1 is carried out. This analysis does not include correction factors for source anisotropy and tubing attenuation which were reported by Tech Ops (Reference 2) after the RTI analysis was completed. An evaluation of the errors associated with scaling up the experimental results is presented in Section II. It was estimated that the scaled-up data should be multiplied by about 1.04 to account for scaling errors for 20 psf mass thicknesses. The variation of dose rate with width of the contaminated field is discussed in Section III. It was found that calculations made using the Engineering Manual underestimated the measured dose rates by about the same amount as that noted by Tech Ops when using the Computer Program. The relative magnitude of the underestimate increased as the width of the plane became smaller. The increasing

discrepancy for close-in narrow planes from which the direct radiation must pass through a floor to reach the detector is believed to be due in part to an inaccuracy in estimating the attenuation of direct radiation. An alternative method is suggested in Section III for approximating the combined wall and floor barrier factor. Details of all calculations are presented in the TABS.

II. EVALUATION OF SCALING ERRORS

A. Introduction

Several criteria must be satisfied in order for scaled-up model data to be representative of a full-scale experiment. If these criteria are not met, a discrepancy between scaled-up data and calculations on a full-scale structure may be due both to scaling errors and to errors in the computational procedure. Therefore, before comparing the data with full-scale calculations, it was necessary to estimate scaling errors which were not evaluated quantitatively by Tech Ops.

B. Air Density Effects on Scaling

The scaling laws are difficult to satisfy and were not entirely obeyed in the Tech Ops experiments (see p. 57, Reference 1). The model accurately simulated the full-scale building in geometry and mass-thickness; however, it was not possible to increase the air density to achieve the same mass thickness between the source and building in the model as would exist in the full-scale case. The error due to this effect was essentially eliminated by a computational technique presented in Reference 1. An ambiguity remains in determining the proper thickness of steel to simulate the full-scale walls and floors. Steel has neither the scaled-up density nor the same scattering and absorption cross sections as that used for the attenuation curves in the A&E Guide and Engineering

Manual. In the current analysis, the model and full-scale structure were assumed to have the same mass thicknesses.

C. Comparison of Experimental Data with Computations in Model and Full-Scale Geometry

The height of the scale model (6 ft) was sufficient to allow a direct calculation of the reduction factor (RF) with the Engineering Manual using the actual dimensions of the model. It was expected that the calculated RF would not agree precisely with the observed data owing to the facts that: (a) some simplifying assumptions had to be made in developing the manual; (b) iron was used in the model, whereas, the manual is based on water; and (c) nearly monoenergetic gammas were used in the experiment rather than a fallout spectrum. The RF at a point midway between the 4th and 5th floors (3½ ft above ground level) in the center of the model building was determined from the data to be 0.53 (see TAB 1). An Engineering Manual calculation using actual model dimensions gave the result 0.43 (see TAB 2). If no errors were introduced in scaling up the data to a full-size structure, the ratio of the RF obtained from the scaled-up data to that calculated with the manual for the full-scale case would be the same as the above ratio 0.53/0.43 = 1.23. The RF from the scaled-up data for the same location in the building was 0.216 (see TAB 3), whereas, the RF calculated with the manual for the full-scale building was 0.183 (see TAB 4). Comparison of this ratio (0.216/0.183 = 1.18) with 1.23 above indicates that the correction factor needed due to the scaling error is approximately 1.04. The correction associated with this factor (4 percent) is of the order of the scatter of dosimeter readings (5 percent), (p. 16, Reference 1) and probably should be neglected.

III. EVALUATION OF LIMITED FIELD DATA

A. Introduction

The finite field correction in the National Fallout Shelter Survey Computer Program is based on the parameter W_c/H, where W_c is the plane width and H is the detector height. The width is measured from the edge of the building to the outer periphery of the contamination. Tech Ops found that the observed data plotted versus W_c/H fell above the values predicted by the Computer Program. Before revising the program to force agreement with experimental data, it must be ascertained whether a difference should exist due to basic differences in the experimental and computational models.

B. Computational Procedure

The more sophisticated computational procedure of the Engineering Manual is more reliable than the simplified method of the A&E Guide or the Computer Program. Consequently, comparison of the data with predictions based on the manual will give an indication of the basic error to be expected in the Computer Program. Furthermore, scaling errors can be avoided by performing calculations directly in model geometry. The computational procedure is presented in TAB 5. The results for a detector position at the center and midway between the 4th and 5th floors (position E, 3½ ft above the ground) are shown in Figures L1 and L2.) This detector location was chosen because its symmetry greatly simplified computations and its height was very nearly the standard value (3 ft). Not included in this report are analyses of the basement data and the variation in dose rate due to changes in detector height between floor levels and as the detector is moved toward the outer walls.

C. Analysis of Cumulative Data

It is seen in Figure L1 that the theoretical results lie about 15-20

percent below the experimental data for wide planes and lie considerably more below for narrow planes. Since it is believed that Engineering Manual calculations agree rather well with infinite field data for a fallout spectrum and walls with atomic characteristics of water in a simple windowless structure, the above disagreement must be attributed to use of cobalt-60 and steel in the model. It is concluded that the computer program would also underestimate the data by this amount--a fact which was observed by Tech Ops for this detector position (see Figure 19, Reference 1). Therefore, no revision of the Computer Program is needed for this case for wide planes. It is recommended that penetration data such as that presented in the Engineering Manual be developed for the radiations of cobalt-60 and attenuation characteristics of steel. Then, comparison of calculations with model data will shed light directly on the errors associated with the simplifying assumptions made in the manual. Basic data are available for vertical wall barrier factors for cobalt-60 gammas incident on concrete (Figure B25, Reference 6) and a 1.12-hr fission spectrum incident on water (Figure 28.7, Reference 6). The barrier factors for a 20-psf effective mass thickness for these cases are 0.315 (d = 3 ft) and 0.30 (d = 3.3 ft), respectively. These data indicate that computations based on a fission spectrum will underestimate experimental results for cobalt-60 gammas. This trend was observed.

D. Analysis of Data for Individual Source Rings

A comparison of the predicted and measured dose rate from each source ring is shown in Figure L2. Generally, the calculated results fall somewhat below the experimental points. This fact is expected in view of the infinite field comparison (see TABS 1 and 2). Agreement is good for those source rings (numbers 5-11) beyond the floor shadow. On the other hand, the calculated points fall considerably below the experimental points for the close-in rings for which the direct radiation must pass through the 4th floor.

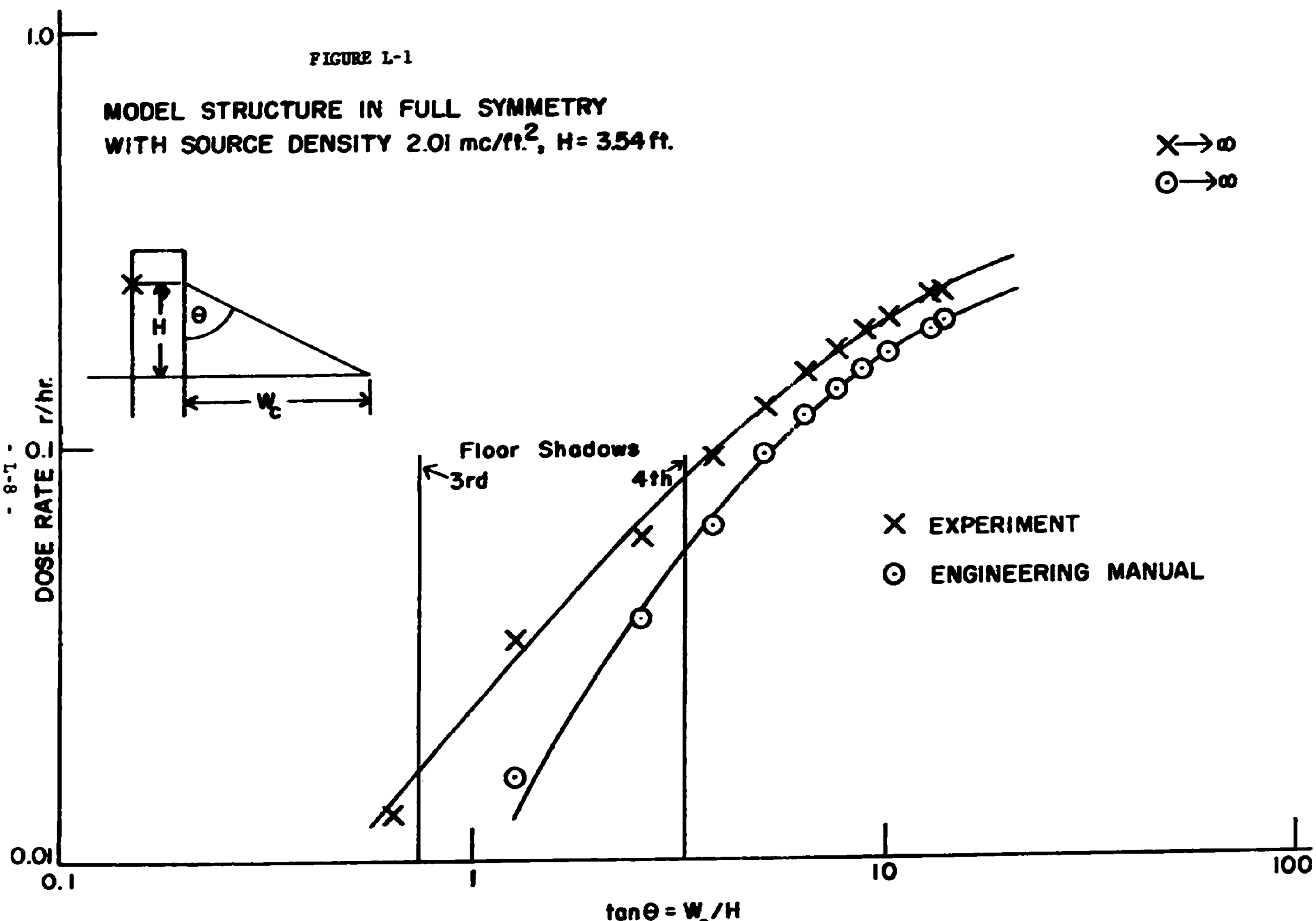
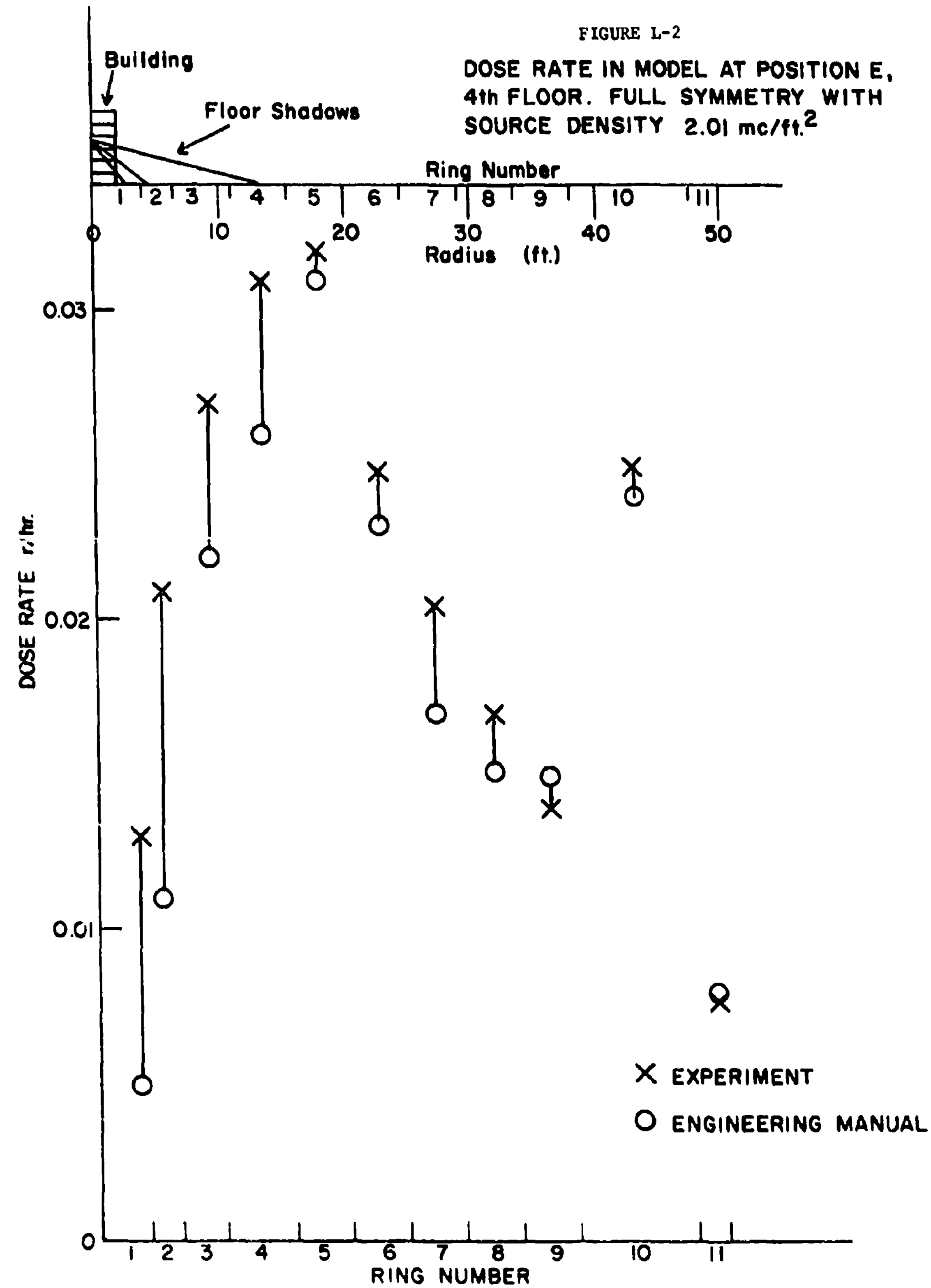


FIGURE L-1

MODEL STRUCTURE IN FULL SYMMETRY
WITH SOURCE DENSITY 2.01 mc/ft.^{2}, H = 3.54 ft.

FIGURE L-2

DOSE RATE IN MODEL AT POSITION E, 4th FLOOR. FULL SYMMETRY WITH SOURCE DENSITY 2.01 mc/ft.^{2}



Comparison of the relative contribution of the direct and scattered radiation for the various source areas indicates that the calculated direct contribution may be underestimated. If the calculated wall-scattered contribution is assumed to be approximately correct, one can estimate what the direct contribution should be from the experimental data. As seen in Table L-I, for ring 2 this value is 0.014 to be compared with the calculated 0.005.

TABLE L-I

Reduction Factors

Ring	Total RF (Experimental)	Scattered (Calculated)	Total Minus Scattered	Direct (Calculated)
2	0.021	0.007	0.014	0.005
3	0.027	0.015	0.012	0.007

Similarly , for ring 3 the calculated direct contribution of 0.007 is less than the 0.012 expected from the experimental data. These results suggest that the product of the barrier reduction factors

$$B_w(X_e,H_1)B_o(X_f) \tag{L1}$$

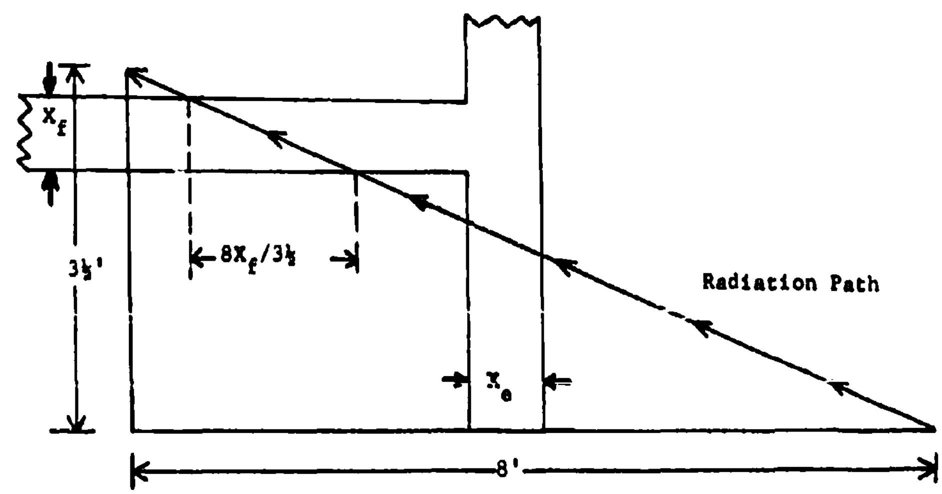
in equation (L21) gives a value too small. It seems reasonable to replace this expression by $B_w(X_e',H_1)$ in which X_e' is the horizontal projection of the combined floor and wall thickness penetrated by the direct radiation (Figure L-3). For ring 3 located 8 ft away from the center of the building, we have ($H = 3\frac{1}{2}$ ft),

$$X_e' = X_e + \frac{8}{H} X_f = 66 \text{ psf} \tag{L2}$$

and $B_w(X_e',H_1) = 0.2$. With this, the calculated direct contribution is 0.012 which is equal to the (total experimental minus wall-scattered) contribution as given in Table L-I.

FIGURE L-3

Path of Direct Radiation From Ring 3



REFERENCES

1. John F. Batter and Albert Starbird. The Effect of Limited Strips of Contamination on the Dose Rate in a Multistory Windowless Building, Volume I, 20 psf Wall and Floor Thickness. Report No. TO-B 62-26, Burlington, Massachusetts: Technical Operations, Inc., April 1962.

2. John F. Batter, Albert W. Starbird and Nancy-Ruth York. Final Report - The Effect of Limited Strips of Contamination on the Dose Rate in a Multistory Windowless Building. Report No. TO-B 62-58. Burlington, Massachusetts: Technical Operations, Inc., August 1962.

3. Office of Civil Defense. Fallout Shelter Surveys: Guide for Architects and Engineers. Washington: Office of Civil Defense, Department of Defense, December 1961.

4. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for the National Fallout Shelter Survey. National Bureau of Standards Report 7539, Washington: U. S. Department of Commerce, 3 July 1962.

5. Office of Civil Defense. Design and Review of Structures for Protection from Fallout Gamma Radiation. (Engineering Manual). Revised Edition; Washington: Office of Civil Defense, Department of Defense, 1 October 1961.

6. L. V. Spencer. Structure Shielding Against Fallout Radiation From Nuclear Weapons. National Bureau of Standards Monograph 42. Washington: U. S. Department of Commerce, 1 June 1962.

7. Richard Stephenson, Introduction to Nuclear Engineering. 2nd ed.; New York: McGraw-Hill Book Company, Inc., (1958) 197.

8. R. E. Rexroad and M. A. Schmoke. Scattered Radiation and Far-Field Dose Rates from Distributed Cobalt-60 and Cesium-137 Sources. Report No. NDL-TR-2. Edgewood, Maryland: Nuclear Defense Laboratory, Army Chemical Center, September 1960.

9. Herbert Goldstein. Fundamental Aspects of Reactor Shielding. Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., (1959) 235.

TAB 1

Experimental Reduction Factor in Model

I. PROCEDURE

The reduction factor (RF) is defined as the ratio of the dose rate at a sheltered point to the dose rate outside at 3 ft above a smooth area of infinite extent uniformly contaminated with fallout. The Tech Ops data in Tables 1 through 22 of Reference 1, are normalized so that they represent dose rates in r/hr for a source strength of 1 curie/ft^2. In order to obtain the RF for a point located midway between the fourth and fifth floors (Table 14, Reference 1) at the center (position E), it is necessary to determine the far-field contribution to the measured dose rate from that region beyond the outermost source area 27 and to calculate the dose rate at 3 ft above an infinite field with source intensity 1 curie/ft^2.

II. DOSE RATE ABOVE AN INFINITE PLANE

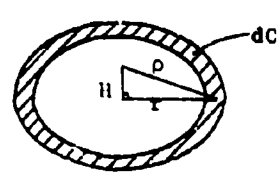
Consider first the dose rate above an infinite plane. The dose rate at ρ ft away from a point source of strength C curies with no attenuation is (Reference 7):

$$D = 6\ CE/\rho^2\ ,\ r/hr \qquad (L3)$$

in which E is the gamma energy, Mev/disintegration. The dose rate at H

FIGURE L-4

Geometry for Infinite Plane Calculation



above the plane in Figure L-4 due to the element of source dC on the strip in the plane is

$$dD = 6E\ B(\mu_o \rho)\ e^{-\mu_o \rho} dC/\rho^2 \tag{L4}$$

in which $dC = 2\pi r dr \sigma$, where σ is the source intensity in curies/ft^2. The buildup factor $B(\mu_o \rho)$ and exponential factor account for multiple scattering and absorption in air. From Figure L-4 we see

$$\rho^2 = H^2 + r^2 \tag{L5}$$

from which

$$\rho d\rho = r dr\ . \tag{L6}$$

Integrate equation (L4) to obtain the dose rate for an infinite plane

$$D = 12\pi\sigma E \int_{\mu_o H}^{\infty} \frac{B(x)}{x}\ e^{-x}\ dx \tag{L7}$$

in which equation (L6) was inserted and $\mu_o \rho$ was replaced by x. The buildup factor for a point cobalt-60 source on the ground is (Reference 8)

$$B(x) = 1.11 + 0.529\ x + 0.157 e^{-86.1x}\ . \tag{L8}$$

Integration of equation (L7) with B(x) replaced by equation (L8) gives

$$D = 12\pi E\,\sigma\,[1.11E_1(\mu_o H) + 0.529 e^{-\mu_o H} + 0.157E_1(87.1\mu_o H)]. \tag{L9}$$

Values of the E_1 functions are available in Appendix C of Reference 9. For cobalt-60 we have $6E = 14$, $\mu_o/\rho_d = 0.0567$ cm^2/gm for 1.25 mev photons (Reference 9) and $\rho_d = 1.25$ gm/liter for air at 50°F (assumed). The reciprocal mean free

path is $\mu_o = 0.0567 \times 0.00125 \times 30.5 = 0.00216\ ft^{-1}$. At H = 3 ft, equation (L9) reduces to

$$D = 490\sigma \tag{L10}$$

which states that a unit source intensity $\sigma = 1$ curie/ft^2 will produce a dose rate of 490 r/hr at 3 ft above the infinite plane source. This compares favorably with the value 497 r/hr quoted on p. 17, Reference 1, and used by Tech Ops for normalization purposes. The small difference is probably due to the use of a different air temperature and representation for the buildup factor. For subsequent calculations the 497 value will be used.

III. FAR-FIELD CONTRIBUTION

Consider next the far-field contribution. Knowledge of the ratio of the dose rate due to the source beyond $r_o = 50.2$ ft to that due to the source in the ring between $r_i = 47.7$ ft and $r_o = 50.2$ ft (outermost source area 27 in Table 14, Reference 1) would permit the calculation of the far-field effect using the dose rate measured in the outermost ring. This ratio can be estimated by neglecting the presence of the building. The dose rate due to the ring is (see Figure L-4 and Equation (L7)):

$$D(r_i \longrightarrow r_o) = 12\pi\sigma E \int_{\mu_o\rho_i}^{\mu_o\rho_o} \frac{B(x)}{x} e^{-x}\, dx \tag{L11}$$

in which ρ_i and ρ_o are the slant radii given by equation (L5). For distances ρ of the order of 50 ft, the exponential term in (L8) can be dropped. Therefore, we obtain

$$\frac{D(r_o \longrightarrow \infty)}{D(r_i \longrightarrow r_o)} = \frac{1.11\ E_1(\mu_o\rho_o) + 0.529 e^{-\mu_o\rho_o}}{1.11[E_1(\mu_o\rho_i) - E_1(\mu_o\rho_o)] + 0.529(e^{-\mu_o\rho_i} - e^{-\mu_o\rho_o})} . \tag{L12}$$

With $H = 3\frac{1}{2}$ ft, $\mu_o = 0.00216\ ft^{-1}$, $\rho_i = 47.8$ ft, and $\rho_o = 50.3$ ft, we get

$$\frac{D(r_o \longrightarrow \infty)}{D(r_i \longrightarrow r_o)} = 44\ . \qquad \text{(L13)}$$

This ratio can be roughly checked with results from Figure 8 of the Engineering Manual (Reference 5) or p. 32 of the Spencer Monograph (Reference 6).

$$\frac{D(50.3\ ft)}{D(47.8\ ft) - D(50.3\ ft)} \cong \frac{0.5}{0.01} \cong 50\ .$$

The dose rate in the building due to area 27 is 0.84 r/hr (position E, Table 14, Reference 1). The dose rate due to the region beyond area 27 is, therefore, approximately 44 x 0.84 = 37 r/hr.

IV. RF AT CENTER OF FOURTH FLOOR

The dose rate due to all areas outside the building for which measurements were made is 28.9 r/hr obtained by summing all values in columns E in Table 14 of Reference 1. Hence for quarter symmetry, the infinite field dose rate is 28.9 + 37 = 66 r/hr, and for full circular symmetry it is 4 x 66 = 264 r/hr. The reduction factor is the ratio of this to the dose rate at H = 3 ft in the absence of the building previously found to be 497 r/hr.

$$RF = 264/497 = 0.53\ . \qquad \text{(L14)}$$

It is noted that the far-field contribution comprises 56 percent (37/66) of the total dose rate. Consequently, an error in its estimate will seriously affect the accuracy of the total dose rate. The presence of the building with attenuating walls has the effect of making the actual dose ratio $D(r_o \longrightarrow \infty)/D(r_i \longrightarrow r_o)$ less than that estimated with equation (L13) for no building. This is due to the fact that the lower energy multiple scattered radiation coming from the far-field

region will be attenuated more by the walls than the more direct radiation from the nearer sources. Thus, the RF in equation (L14) should be reduced somewhat.

TAB 2

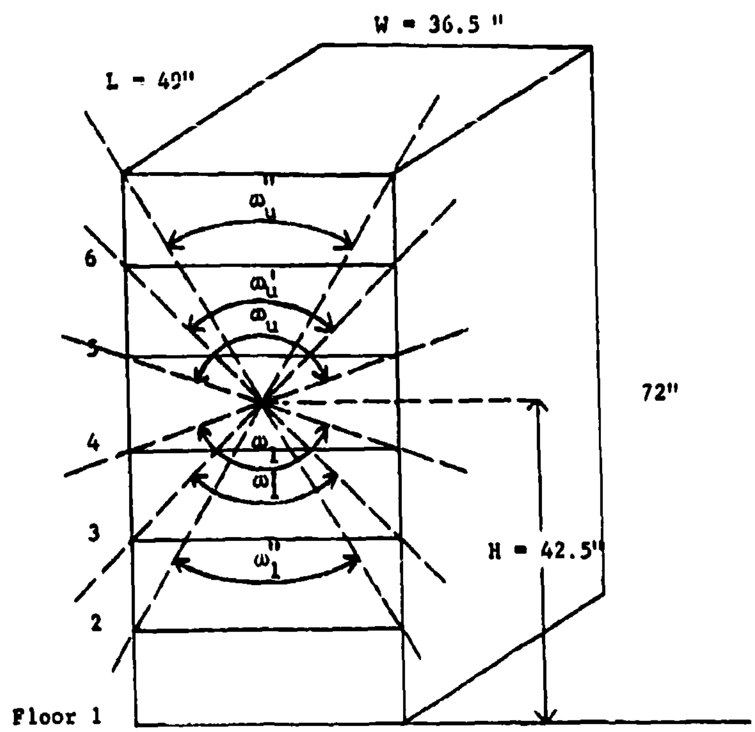
Theoretical Reduction Factor in Model

I. MODEL DESCRIPTION

The model dimensions are great enough to permit a direct calculation of the reduction factor. The building is schematized in Figure L-5. The detector is

FIGURE L-5

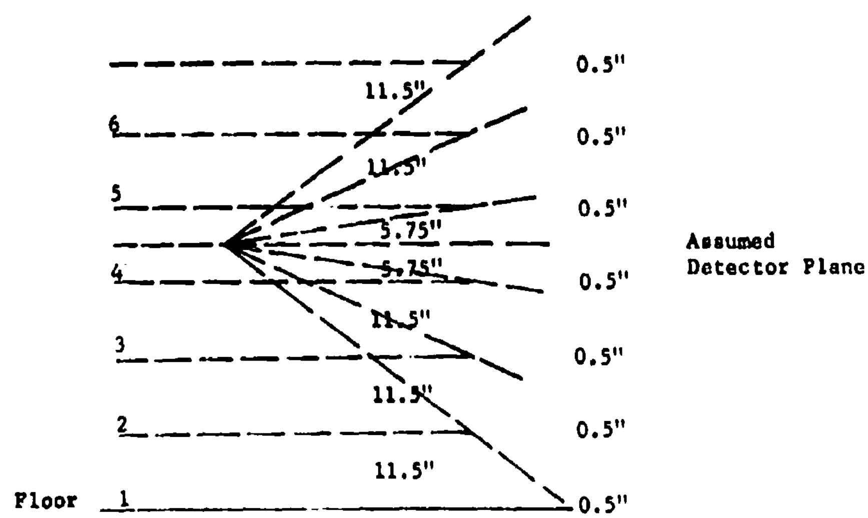
Model Structure ($X_f = X_w = X_e = 20$ psf)



located approximately at the center of the volume between the 4th and 5th floors (position E, 6 in. above 4th floor) which is 42.5" = 3.54 ft above the ground. Dimensions are obtained from Figure 3, Reference 1. A detail showing room heights and floor thicknesses in inches for solid angle fraction computations is presented in Figure L-6.

FIGURE L-6

Detail for Solid Angle Fraction Calculations



II. REDUCTION FACTOR CALCULATIONS

The reduction factor is calculated according to the procedure presented in Example No. 7 of the Engineering Manual. The requisite data are tabulated in Table L-II, and the calculations are in Table L-III. Extrapolations were made in Charts 2 and 6 of the Engineering Manual to obtain data for heights below 3 ft. The calculated reduction factor is 0.43.

TABLE L-II

Model Data from Engineering Manual
(All references are to Reference 5)

	e=W/L	n=2Z/L	ω Chart 3	$G_d(\omega_1, H)$ (H=3.54') Chart 6	$G_s(\omega)$ Chart 5	$G_a(\omega_u)$ Chart 5
$\omega_u = \omega_1$	36.5/49 =0.746	2x5.75/49 =0.224	0.77	0.58	0.236	0.060
$\omega_u' = \omega_1'$	0.746	2x17.75/49 =0.725	0.39	0.78	0.410	0.089
$\omega_u'' = \omega_1''$	0.746	2x29.75/49 =1.21	0.22	0.84	0.452	0.095

H (ft)	$B_w(X_e=20, H)$ Chart 2
1.54	0.65
2.54	0.62
3.54	0.59
4.54	0.57
5.54	0.55

X_f, X_o' (psf)	$B_o(X_f)$ Chart 1 Case 1	$B_o'(X_o')$ Chart 1 Case 3
20	0.20	0.25
40	(.11	0.10

$S_w(X_e = 20) = 0.35$ (Chart 7)

$E\ (e = 0.746) = 1.4$ (Chart 8)

$C_o(\omega_o = \omega_u' = 0.22,\ X_o = 60) = 0.04$ (Chart 4)

Skyshine factor for decontaminated roof with $X_o = 60$ is 0.07 (page 17).

TABLE L-III

Engineering Manual Calculations for Model (X_e = 20 psf, H = 3.54 ft)

Through 4th floor walls (adjacent)

$$\left[G_s(\omega_u) + G_s(\omega_l)\right] S_w E = (0.236 + 0.236) \times 0.35 \times 1.4 = 0.231$$

$$\left[G_a(\omega_u) + G_d(\omega_l, H)\right] (1-S_w) = (0.060 + 0.58) \times 0.65 = 0.415$$

$$C_g = G_g\ B_w(X_e, H) = (0.231 + 0.415) \times 0.59 = \underline{0.38}$$

Through 5th floor walls (ceiling) (H_u = 4.54, X_o' = 20)

$$\left[G_s(\omega_u') - G_s(\omega_u)\right] S_w E = (0.41 - 0.236) \times 0.35 \times 1.4 = 0.085$$

$$\left[G_a(\omega_u') - G_a(\omega_u)\right] (1-S_w) = (0.089 - 0.060) \times 0.65 = 0.0188$$

$$C_g = G_g\ B_w(X_e, H_u)\ B_o'(X_o') = (0.085 + 0.0188) \times 0.57 \times 0.25 = \underline{0.015}$$

Through 6th floor walls (ceiling) H_u = 5.54', X_o' = 40)

$$\left[G_s(\omega_u'') - G_s(\omega_u')\right] S_w E = (0.452 - 0.410) \times 0.35 \times 1.4 = 0.021$$

$$\left[G_a(\omega_u'') - G_a(\omega_u')\right] (1-S_w) = (0.095 - 0.089) \times 0.65 = 0.004$$

$$C_g = G_g\ B_w(X_e, H_u)\ B_o'(X_o') = (0.021 + 0.004) \times 0.55 \times 0.1 = \underline{0.001}$$

Roof Contribution ($\omega_o = \omega_u''$, X_o = 60)

$$(\text{Skyshine factor}) \times C_o(\omega_o, X_o) = 0.07 \times 0.04 = \underline{0.003}$$

Through 3rd floor walls (H_l = 2.54, X_f = 20)

$$\left[G_s(\omega_l') - G_s(\omega_l)\right] S_w E = 0.085 \quad \text{(same as 5th floor)}$$

$$\left[G_d(\omega_l', H) - G_d(\omega_l, H)\right] (1-S_w) = (0.78 - 0.58) \times 0.65 = 0.13$$

$$C_g = G_g\ B_w(X_e, H_l)\ B_o(X_f) = (0.085 + 0.13) \times 0.62 \times 0.20 = \underline{0.027}$$

Through 2nd floor walls (H_l = 1.54, X_f = 40)

$$\left[G_s(\omega_l'') - G_s(\omega_l')\right] S_w E = 0.021 \quad \text{(same as 6th floor)}$$

$$\left[G_d(\omega_l'', H) - G_d(\omega_l', H)\right] (1-S_w) = (0.84 - 0.78) \times 0.65 = 0.039$$

$$C_g = G_g\ B_w(X_e, H_l)\ B_o(X_f) = (0.021 + 0.039) \times 0.65 \times 0.11 - \underline{0.004}$$

Through 1st floor walls

Negligible

Sum of C_g's = Reduction Factor

$$RF = 0.38 + 0.015 + 0.001 + 0.003 + 0.027 + 0.004 = \underline{\underline{0.43}}$$

TAB 3

Conversion of Model Data to Full-Scale Data

I. CONVERSION METHOD

The model data were scaled up by Tech Ops and presented graphically. In order to obtain precise numerical values for the purposes of this report, the data are scaled up herein, following the method presented in Reference 1, p. 57. The basic method consists of multiplying the measured dose rate for an area by a ratio R which converts the model dose rate to the full-scale dose rate. The ratio R accounts for the difference in air attenuation in the model and that for the full-scale structure. It is estimated by evaluating the dose rate in the absence of the building for each case in a manner similar to that presented in TAB 1 for the far-field correction. For simplicity, the source areas are converted to circular strips or rings having the same area. The conversion ratio R for each of the areas is listed in Reference 1, p. 62.

II. DATA CONVERSION

The scaling computations are shown in tabular form in Table L-IV. The experimental data are taken from Table 14, position E, Reference 1, and the ratio R is that for a height of 3½ ft in the model. The full-scale data in the 5th column in Table L-IV are normalized so that they represent dose rates for full-symmetry contamination with a source intensity that will produce a dose rate of 1 r/hr at 3 ft above an infinite plane. The model data in the 4th column are based on a source density of 1 curie/ft^2 in quarter symmetry. Since an infinite field with this unit density will produce a dose rate of 497 r/hr, the normalizing factor is 4/497 = 0.00804 which appears in the heading of column 5. The cumulative full-scale experimental dose rate in the last column indicates that the

dose rate in an infinite field surrounding the model is 0.216 r/hr. The ratio of 0.216 r/hr to the infinite field dose rate 1 r/hr gives the reduction factor 0.216 for the full-scale building at the center of the volume between the 4th and 5th floors.

TABLE L-IV

Scaled-Up Data for Position E, 6 ft above 4th Floor
(All references are to Reference 1)

Ring No.	Source Areas	[1] FS/Model Ratio R at 3.5 ft (Table 27)	[2] Exp. Dose Rate (Table 14)	Full-Scale Dose Rate = 0.008 x [1] x [2]	Cumulative Full-Scale Exp. Dose Rate
1	A,C,G	0.97	1.652	0.0129	0.0129
2	B,D,F,E,H	0.95	2.617	0.0200	0.033
3	4,5,6	0.90	3.36	0.0242	0.057
4	7,8,9	0.85	3.89	0.0265	0.084
5	10,11,12	0.79	3.96	0.0252	0.109
6	13,14,15	0.74	3.07	0.0182	0.127
7	16,17,18	0.68	2.54	0.0138	0.141
8	19,20,21	0.63	2.09	0.0105	0.151
9	22,23,24	0.57	1.75	0.0080	0.159
10	25,26	0.62	3.14	0.0156	0.175
11	27	0.48	0.84	0.0032	0.178
12	Far-field	5.6*	-	0.0378	0.216

*Ratio of full-scale far-field dose rate to model data for area 27 (see Table 28, Reference 1).

TAB 4

Theoretical Reduction Factor in Full-scale Building

The computational method follows that presented in TAB 2 for the model. The full-scale structure is represented by Figure L-5 with inches replaced by feet. The walls and floors have mass thicknesses of 20 psf and are assumed to occupy negligible volume. The detector is located 6 feet above the 4th floor which is 42 feet above the contaminated plane. The contribution penetrating other than the 3rd, 4th, and 5th floor walls is neglected. The requisite data appear in Table L-V and the computations are in Table L-VI. The calculated reduction factor is 0.183.

TABLE L-V

Full-Scale Data From Engineering Manual
(All references are to Reference 5)

	$c = W/L$	$n=2Z/L$	ω Chart 3	$G_d(\omega_l,H)$ $(H=42')$ Chart 6	$G_s(\omega)$ Chart 5	$G_a(\omega_u,H)$ $(H=42')$ Chart 5
$\omega_u = \omega_l$	36.5/49 =0.746	2x6/49 =0.245	0.75	0.32	0.25	0.062
$\omega_u' = \omega_l'$	0.746	2x18/49 =0.735	0.39	0.64	0.41	0.089
ω_u''	0.746	2x30/49 =1.22	0.22			

$S_w(X_o = 20) = 0.35$ (Chart 7)

$E(c = 0.746) = 1.4$ (Chart 8)

$B_o(X_f = 20) = 0.2$ (Chart 1, Case 1)

$B_o'(X_o' = 20) = 0.25$ (Chart 1, Case 3)

$C_o(\omega_o = \omega_o'' = 0.22, X_o = 60) = 0.04$ (Chart 4)

Skyshine factor for decontaminated roof with $X_o = 60$ is 0.07 (page 17)

H (ft)	$B_w(X_e=20,H)$ Chart 2
30	0.35
42	0.31
54	0.29

TABLE L-VI

Engineering Manual Calculations for Full-Scale Building

(X_e = 20 psf, H = 42 ft)

Through 4th floor walls (adjacent)

$\left[G_s(\omega_u) + G_s(\omega_l)\right] S_w E = (0.25 + 0.25) \times 0.35 \times 1.4 = 0.245$

$\left[G_a(\omega_u) + G_d(\omega_l, H)\right] (1-S_w) = (0.062 + 0.32) \times 0.65 = 0.248$

$C_g = G_g B_w(X_e, H) = (0.245 + 0.248) \times 0.31 = \underline{0.153}$

Through 5th floor walls (ceiling) (H_u = 54', X_o' = 20)

$\left[G_s(\omega_u') - G_s(\omega_u)\right] S_w E = (0.41 - 0.25) \times 0.35 \times 1.4 = 0.078$

$\left[G_a(\omega_u') - G_a(\omega_u)\right] (1 - S_w) = (0.089 - 0.062) \times 0.65 = 0.0175$

$C_g = G_g B_w(X_e, H_u) B_o'(X_o') = (0.078 + 0.0175) \times 0.29 \times 0.25 = \underline{0.007}$

Through 3rd Floor walls (floor) (H_l = 30', X_f = 20)

$\left[G_s(\omega_l') - G_s(\omega_l)\right] S_w E = 0.078$ (same as 5th floor)

$\left[G_d(\omega_l', H) - G_d(\omega_l, H)\right] (1-S_w) = (0.64 - 0.32) \times 0.65 = 0.208$

$C_g = G_g B_w(X_e, H_l) B_o(X_f) = (0.078 + 0.208) \times 0.35 \times 0.2 = \underline{0.020}$

Roof Contribution (decontaminated) ($\omega_o = \omega_u''$, X_o = 60)

(Skyshine factor) $\times C_o(\omega_o, X_o) = 0.07 = 0.07 \times 0.04 = \underline{0.003}$

Sum of C_g's = Reduction Factor

$RF = 0.153 + 0.007 + 0.020 + 0.003 = \underline{0.183}$

TAB 5

Experimental and Theoretical Dose Rates From Limited Strips in Model

I. EXPERIMENTAL CONTRIBUTION

The experimental dose rates as a function of ring number are presented in Table L-VII in the column labeled [7]. These data come directly from Table 14, Reference 1, for position E. Thus for ring number 1, which consists of source areas A, C, and G (see Figure 4, Reference 1), the experimental dose rate is $0.662 + 0.500 + 0.490 = 1.65$ r/hr. The next column in Table L-VII labeled, "Experimental Contribution," is obtained by normalizing the data to account for full symmetry and a source density 1/497 curies/ft^2 (see TAB 3). The Cumulative Experimental Contribution is a sum of the "Experimental Contribution" column and is plotted versus the ratio of the contaminated strip width, W_c, to the detector height, H, in Figure L-1.

II. THEORETICAL CONTRIBUTION

A. Source Rings

The width, W_c, of a washer-shaped strip of contamination which surrounds and extends outward from a cylindrical structure is defined as the difference of the outer radius of the strip and the building radius. The equivalent radii of the source regions are obtained by replacing the actual rectangular regions with concentric strips or rings that have the same area. For example, the total area enclosed by the outer radius of ring number 3 is 95 ft^2 in quarter symmetry. Hence its radius is 11.0 ft calculated from $\pi r_o^2 = 95 \times 4$ (see columns [1] and [2] in Table L-VII). The cumulative strip which includes rings 1, 2, and 3 has width $W_c = 11.0 - 1.955 = 9.0$ ft, and ratio $W_c/H = \tan\theta = 9.0/3.54 = 2.56$, which is also entered in Table L-VII.

TABLE L-VII

Theoretical and Experimental Dose Rate in the Model (H=3.54)

Ring Number	Source Areas	[1] Cumulative Area from Fig. 4	[2] Outer Radius $r_o = \frac{2}{\sqrt{\pi}} [1]^{\frac{1}{2}}$	$1 - \omega = \frac{H}{(H^2+r_o^2)^{\frac{1}{2}}}$	$G_d(\omega,H)$ (Chart 6)
	Inside Bldg. Walls	(Ref. 1)	1.941	0.123	(Ref. 5) 0.867
	Nominal Bldg.	3	1.955	0.125	0.865
	2nd Fl. Shadow		2.74	0.210	0.840
1	A, C, G	14	4.225	0.358	0.791
	3rd Fl. Shadow		4.58	0.389	0.781
2	B,D,F,E,H	33	6.49	0.521	0.730
3	4, 5, 6	95	11.0	0.694	0.641
	4th Fl. Shadow		13.75	0.751	0.598
4	7, 8, 9	189	15.5	0.777	0.569
5	10, 11, 12	315	20.0	0.826	0.505
6	13, 14, 15	473	24.55	0.857	0.459
7	16, 17, 18	663	29.0	0.879	0.423
8	19, 20, 21	885	33.6	0.895	0.395
9	22, 23, 24	1139	38.1	0.907	0.367
10	25, 26	1788.2	47.7	0.926	0.323
11	27	-	50.2	0.930	0.310
12	Far-Field	-	∞	1.00	0

TABLE L-VII (continued)

Theoretical and Experimental Dose Rate in the Model (H=3.54)

Ring Number	ΔG_d	$\tan\theta = W_c/H = \frac{[2] - 1.955}{3.54}$	$\omega_s = \frac{1-\cos\theta}{2}$	$B_{ws}(X_w=20,\omega_s)$ (Fig. L-9)	ΔB_{ws}	[3] Scattered Contribution From Adjacent Walls $= 0.245\ \Delta B_{ws}$
	-	-	-	-	-	-
	-	-	-	-	-	-
2nd Fl.	0.025	-	-	-	-	-
1	0.049	0.64	0.080	0.0075	0.0075	0.0018
3rd Fl.	0.010	0.74	-	-	-	-
2	0.051	1.28	0.193	0.030	0.023	0.0055
3	0.089	2.56	0.318	0.084	0.054	0.013
4th Fl.	0.043	3.28	-	-	-	-
4	0.029	3.81	0.373	0.124	0.040	0.010
5	0.064	5.08	0.404	0.146	0.022	0.005
6	0.046	6.38	0.423	0.163	0.017	0.004
7	0.036	7.63	0.435	0.175	0.012	0.003
8	0.028	8.92	0.444	0.186	0.011	0.003
9	0.028	10.2	0.451	0.199	0.013	0.003
10	0.044	12.9	0.461	0.223	0.024	0.006
11	0.013	13.6	0.463	0.230	0.007	0.0017
12	-	-	-	-	-	-

TABLE L-VII (continued)

Theoretical and Experimental Dose Rate in the Model (H=3.54)

Ring Number	$\tan\theta_l = \frac{W_c}{2.54}$	$\omega_{sl} = \frac{1-\cos\theta_l}{2}$	$B_{ws}(X_w=20,\omega_{sl})$ (Fig. L-9 of this report)	ΔB_{ws}^{l}	$\tan\theta_u = \frac{W_c}{4.54}$	$\omega_{su} = \frac{1-\cos\theta_u}{2}$
	-	-	-	-	-	-
	-	-	-	-	-	-
2nd Fl.	-	-	-	-	-	-
1	0.89	0.127	0.015	0.015	0.50	0.053
3rd Fl.	-	-	-	-	-	-
2	1.78	0.256	0.052	0.037	1.00	0.147
3	3.57	0.365	0.118	0.066	2.00	0.276
4th Fl.	-	-	-	-	-	-
4	5.30	0.408	0.150	0.032	2.97	0.341
5	7.08	0.430	0.170	0.020	3.97	0.378
6	8.89	0.444	0.186	0.016	4.98	0.402
7	10.6	0.451	0.199	0.013	5.95	0.417
8	12.4	0.460	0.222	0.023	6.95	0.429
9	14.2	0.465	0.239	0.017	7.95	0.438
10	18.0	0.472	0.270	0.031	10.1	0.451
11	19.0	0.474	0.280	0.010	10.6	0.453
12	∞	0.5	-	-	∞	0.5

TABLE L-VII (continued)

Theoretical and Experimental Dose Rate in the Model (H=3.54)

Ring Number	$B_{ws}(X_w=20,\omega_{su})$	ΔB^u_{ws}	[4] Scattered Contribution From Upper & Lower Walls $= 0.0196\ (\Delta B^u_{ws} + \Delta B^l_{ws})$	[5] Total Scattered Contribution = [3] + [4]
	-	-	-	-
	-	-	-	-
2nd Fl.	-	-	-	-
1	0.0037	0.0037	0.0004	0.0022
3rd Fl.	-	-	-	-
2	0.019	0.015	0.0013	0.0065
3	0.062	0.043	0.0021	0.015
4th Fl.	-	-	-	-
4	0.101	0.039	0.0014	0.011
5	0.128	0.027	0.0009	0.006
6	0.144	0.016	0.0006	0.005
7	0.156	0.012	0.0003	0.003
8	0.169	0.013	0.0007	0.004
9	0.180	0.011	0.0005	0.004
10	0.200	0.020	0.0010	0.007
11	0.204	0.004	0.0003	0.002
12	-	-	-	-

TABLE L-VII (continued)

Theoretical and Experimental Dose Rate in the Model (H=3.54)

Number	[6] Contribution From Direct Radiation =0.384 Δ G_d	[7] Experimental Dose Rate (Table 14) (Ref. 1)	Experimental Contribution = 0.008 [7]	Theoretical Contribution = [5] + [6]	Cumulative Experimental Contribution	Cumulative Theoretical Contribution
	-	-	..	..	-	-
	..	-	-	-	-	-
2nd Fl.	0.0007∅	-	-	..	-	-
1	0.0023∅	1.65	0.013	0.005	0.013	0.005
3rd Fl.	0.0005∅	-	-	..	-	-
2	0.004∅	2.62	0.021	0.011	0.034	0.016
3	0.0072∅	3.36	0.027	0.022	0.061	0.038
4th Fl.	0.0035∅	..	-	-	-	..
4	0.011	3.89	0.031	0.026	0.093	0.064
5	0.025	3.96	0.032	0.031	0.124	0.095
6	0.018	3.07	0.025	0.023	0.149	0.118
7	0.014	2.54	0.0205	0.017	0.170	0.135
8	0.011	2.09	0.017	0.015	0.186	0.150
9	0.011	1.75	0.014	0.015	0.200	0.165
10	0.017	3.14	0.025	0.024	0.225	0.189
11	0.0050	0.84	0.0068	0.007	0.232	0.196
12	·	37.*	0.30	-	0.53	0.43+

∅ See p.23 of Ref.5 for computational method

* See TAB 1

+ See TAB 2

B. Source Ring Contributions

The remaining columns in Table L-VII are steps in the theoretical calculation of the contribution to be expected from each source ring. Consider first those source areas from which the direct radiation penetrates the adjacent (fourth floor) walls. It is seen in Figure L-2 and Table L-VII that rings Nos. 5 - 11 fall in this category. If the building were surrounded by an infinite field of radiation, the contribution through the adjacent walls would be (see p. 22, Reference 5)

$$C_g = B_w(X_e, H)\, G_g \tag{L15}$$

in which

$$G_g = [G_s(\omega_l) + G_s(\omega_u)]\; S_w(X_e)\, E(e) + [G_d(\omega_l, H) + G_a(\omega_u)][1 - S_w(X_e)] \;.$$

The first term in G_g accounts for the wall-scattered radiation and the second term accounts for the direct and skyshine radiation.

1. Direct Contribution

a. Adjacent Walls

The directional response $G_d(\omega_l, H)$ for the direct radiation is that for a source area beginning at a radius determined by the fourth floor shadow and extending to infinity. The response for a finite band whose inner and outer radii subtend solid angle fractions ω_i and ω_j is the difference

$$\Delta G_d = G_d(\omega_i, H) - G_d(\omega_j, H) \tag{L16}$$

and the direct contribution from equation (L15) is

$$\Delta G_d (1 - S_w)\; B_w(X_e, H) \;. \tag{L17}$$

The solid angle fraction associated with the outer radius r_j of the j ring is

$$\omega_j = 1 - \frac{H}{(H^2 + r_j^2)^{1/2}} . \qquad \text{(L18)}$$

Thus, ω for ring No. 11 with outer radius 50.2 ft and H = 3.54 ft is 0.930. The detector response $G_d(\omega = 0.930, H = 3.54)$ for the far-field source is 0.310. This value comes from Figure L-7 which is a graph of $G_d(\omega , H = 3.54)$ versus ω . The data for this graph were taken from Chart 6 in the Engineering Manual (Reference 5). Values of G_d for other rings are listed in Table L-VII, together with their differences. Additional data needed are

$$S_w(X_e = 20) = 0.35 \text{ (Chart 7, Reference 5)} \qquad \text{(L19)}$$

$$B_w(X_e = 20, H = 3.54) = 0.59 \text{ (Chart 2, Reference 5)} .$$

With these, the direct contribution for rings Nos. 5 - 11 is

$$(\Delta G_d) (1 - 0.35) \times 0.59 = 0.384 \ \Delta G_d \qquad \text{(L20)}$$

which is tabulated in column [6] .

b. Adjacent and Lower Walls

The outer radius of ring 4 is 15.5 ft and its inner radius is 11.0 ft (see column [2] in Table L-VII). Because the 4th floor shadow is at 13.75 ft, part of the direct radiation from ring 4 penetrates the adjacent (4th floor) wall and the remainder penetrates the 3rd floor wall and 4th floor. The contribution from the area between the shadow and outer radius is 0.011 which was calculated using equation (L20). The contribution through the floor is

$$\Delta G_d \ (1-S_w) \ B_w(X_e,H_1) \ B_o(X_f) . \qquad \text{(L21)}$$

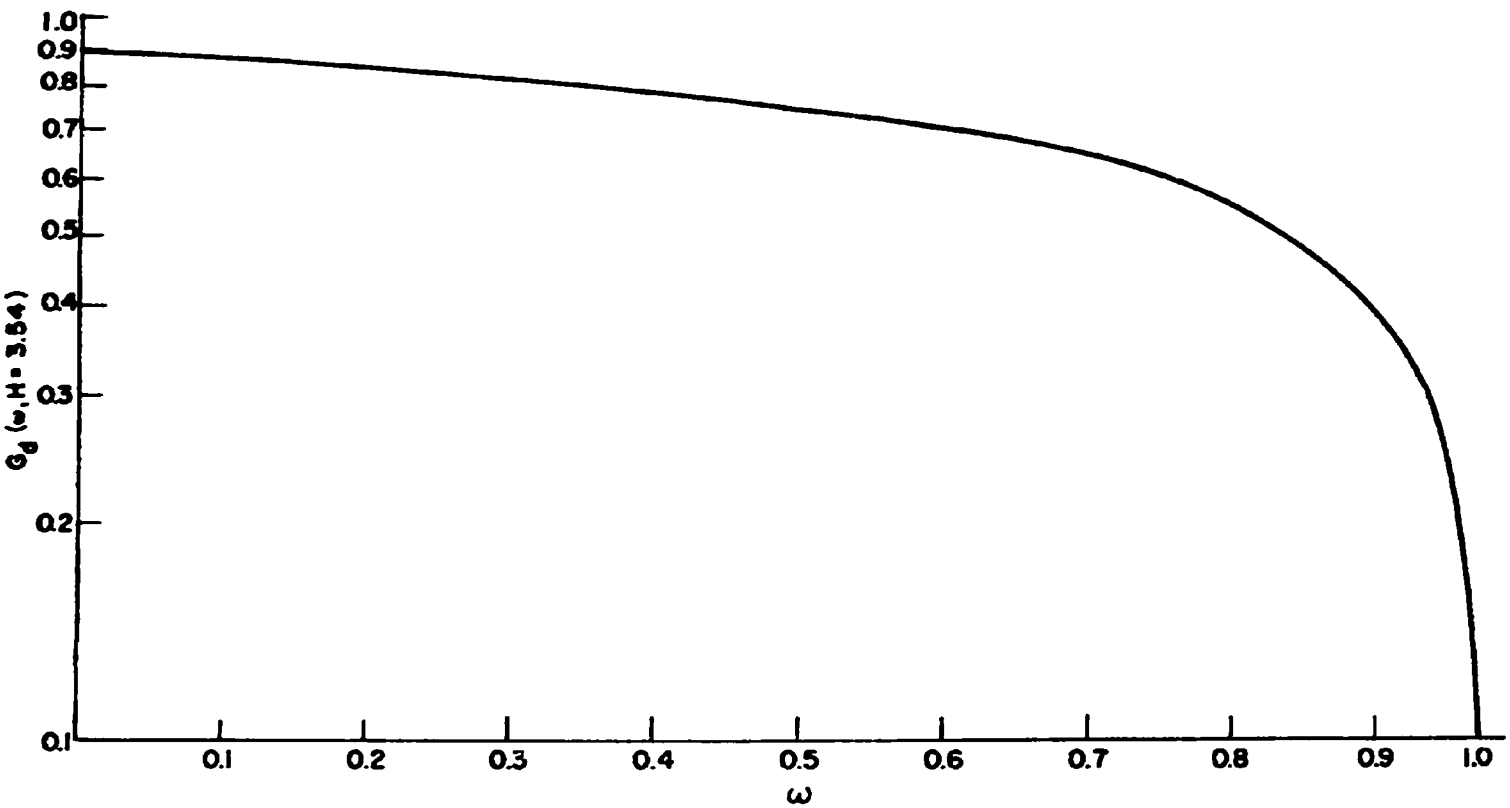


FIGURE L-7

DIRECTIONAL RESPONSE FOR DIRECT RADIATION (Chart 2)

From Chart 2 of the Engineering Manual, $B_w(X_e=20, H_1=2.54)=0.62$, and from Chart 1, Case 1, $B_o(X_f= 20) = 0.2$. The differenced directional response for that part of ring 4 that penetrates the floor is $\Delta G_d = 0.043$ (see Table L-VII) and its contribution according to equation (L21) is

$$0.043\ (1-0.35) \times 0.62 \times 0.2 = 0.0035\,. \qquad \text{(L22)}$$

Thus, the total contribution from the direct radiation from ring 4 is 0.011 + 0.0035 (see Column [6]).

c. Lower Walls

It is noted from column [2] in Table L-VII that all of the direct radiation from ring 3 passes through the 3rd floor walls, whereas that from ring 2 passes through both the 2nd and 3rd floor walls. (See also the sketch in Figure L-2.) Similarly, the direct radiation from ring 1 passes through the 1st and 2nd floor walls. Values needed for these rings are shown in Table L-VIII.

TABLE L-VIII

Data for Direct Contribution

Wall Penetrated	H_1 (ft)	X_f (psf)	$B_w(X_e=20,H_1)$ Chart 2	$B_o(X_f)$ Chart 1 Case 1	$(1-S_w)B_wB_o$ $(S_w=0.35)$
4th	3.54	0	0.59	1.00	0.384
3rd	2.54	20	0.62	0.20	0.081
2nd	1.54	40	0.65	0.11	0.046
1st	0.54	60	0.70	0.06	0.027

The results shown in column [6] of Table L-VII for rings 1 - 4 were calculated with equation (L21) using the data in Table L-VIII.

2. Wall-Scattered Contribution

a. Adjacent Walls

Consider next the wall-scattered radiation. According to equation (L15) the contribution from the adjacent walls is

$$[G_s \ (\omega_l) + G_s \ (\omega_u)] \ \ S_w \ E \ B_w(X_e,H) \qquad \text{(L23)}$$

for a contaminated plane extending from the walls to infinity. If the contamination extends only out to r_j, the wall barrier factor $B_w(X_e,H)$ in equation (L23) must be replaced by $B_{ws}(X_w, \omega_s)$ which is graphed in Chart 9 of Reference 5.

$$[G_s \ (\omega_l) + G_s(\omega_u)] \ \ S_w E \ B_{ws}(X_w, \omega_s) . \qquad \text{(L24)}$$

The solid angle fraction, ω_s, is defined by the area of the limited strip viewed from mid-wall height on a vertical axis on the outer surface of the wall.

In Figure L-8 is shown the portion (cross-hatched) of the limited strip of radius r_j that is seen from a point H ft up the wall of the equivalent cylinderized building. The solid angle fraction ω_s subtended by this area is approximately the same as that subtended by the semicircular area of radius W_c which is

$$\omega_s = \frac{1-\cos\theta}{2} \ . \qquad \text{(L25)}$$

This ω_s and the corresponding $B_{ws}(X_w=20, \omega_s)$ are tabulated in Table L-VII for each source area. The values of B_{ws} were taken from the graph in Figure L-9 for B_{ws} $(X_w=20, \omega_s)$ versus ω_s which was plotted from data in Chart 9, Reference 5. The contribution due to the scattered radiation from the adjacent wall for ring j

with inner radius r_i and outer radius r_j, calculated by differencing equation (L24), is

$$[G_s(\omega_l) + G_s(\omega_u)]\ S_w E\ \ \Delta B_{ws} \qquad \text{(L26)}$$

in which

$$\Delta B_{ws} = B_{ws}(X_w, \omega_{sj}) - B_{ws}(X_w, \omega_{si}) .$$

Values needed for the fourth floor walls are

$\omega_u = \omega_l = 0.75$ (Table L-VII, ω for the 4th floor shadow)

$G_s(\omega_u) = G_s(\omega_l) = 0.25$ (Chart 5, Reference 5)

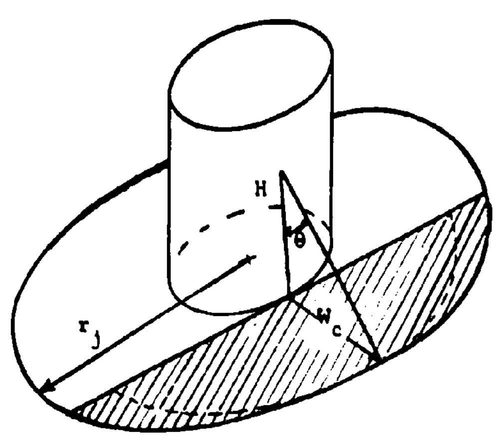
$S_w = 0.35$, $E = 1.4$

$[G_s(\omega_l) + G_s(\omega_u)]\ S_w E\ \ \Delta B_{ws} = 0.245\ \ \Delta B_{ws}$.

The incremental wall barrier factors (ΔB_{ws}) and the contribution from wall-scattered radiation from adjacent walls (0.245 ΔB_{ws}) are entered in Table L-VII.

FIGURE L-8

Cylinderized Building and Source Area



tan θ = W_c/H

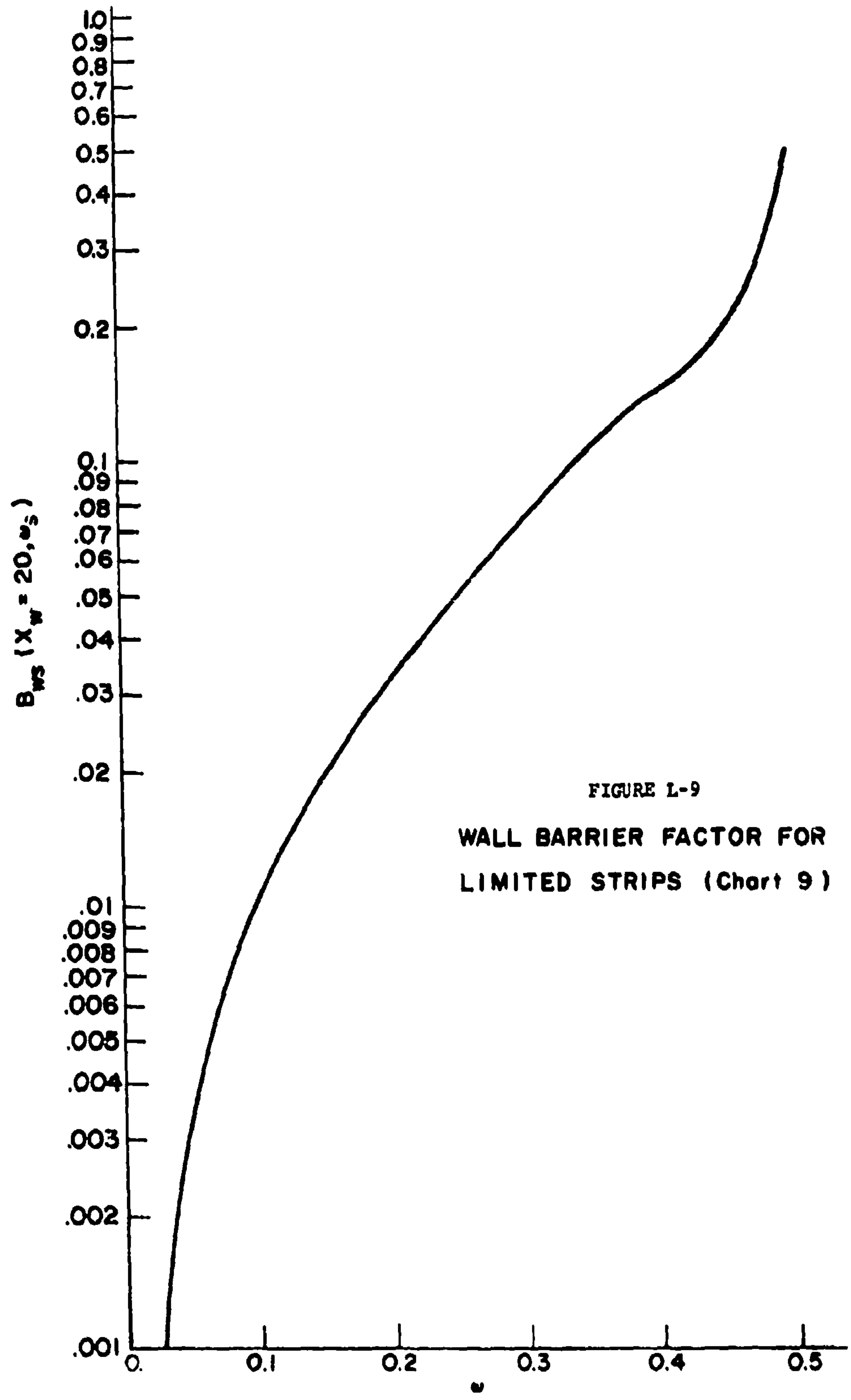


FIGURE L-9

WALL BARRIER FACTOR FOR LIMITED STRIPS (Chart 9)

b. Lower and Upper Walls

The scattered contribution from the 3rd floor walls (lower) is

$$[G_s(\omega_l') - G_s(\omega_l)] \quad S_w \; EB_o'(X_f)B_{ws}(X_e, \omega_{sl}) \tag{L27}$$

and from the 5th floor walls (upper)

$$[G_s(\omega_u') - G_s(\omega_u)] \quad S_w \; EB_o'(X_f)B_{ws}(X_e, \omega_{su}) \; . \tag{L28}$$

In equation (L27), ω_{sl} is the solid angle fraction measured from a reference position at the mid-wall height of the 3rd floor walls. The parameters in equations (L27) and (L28) have the following values:

$\omega_l = \omega_u = 0.75$

$\omega_l' = \omega_u' = 0.39$ (Table L-VII, ω for 3rd floor shadow)

$G_s(\omega_l) = G_s(\omega_u) = 0.25$ (Chart 5, Reference 5)

$G_s(\omega_l') = G_s(\omega_u') = 0.41$ (Chart 5, Reference 5)

$S_w = 0.35$, $E = 1.4$

$B_o'(X_f = 20) = 0.25$ (Chart 1, Case 3)

$[G_s(\omega_l') - G_s(\omega_l)]S_wEB_o(X_f) = 0.0196$.

The scattered contribution from the upper and lower walls for a ring is obtained by differencing equations (L27) and (L28). Inserting numerical values gives

$$0.0196 \; (\Delta B_{ws} + \Delta B_{ws}) \tag{L29}$$

which is tabulated in column [4] of Table L-VII. The total scattered contribution from the adjacent, upper, and lower walls is shown in column [5] for each ring.

3. Total Contribution

The air-scattered contribution in equation (L15) for finite strips is assumed to be negligible. Consequently, the column, "Theoretical Contribution," consists of the sum of the wall-scattered and direct contributions for each ring. The results in this column are compared graphically with the experimental results in Figure L-2.

C. Estimate of Computational Error

It is emphasized that considerable computational accuracy is lost when the directional responses and barrier factors are differenced. For close-in rings the results probably have only one significant figure. This error was minimized by smoothing the data taken from charts as shown in Figures L-7 and L-9.

Appendix M

Discussion of "Technical Operations Research Model Experiment Final Report TO-B 62-58"

This Appendix was originally submitted to OCD as Research Memorandum RM 81-7,* except for minor editorial changes.

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* W. O. Doggett (Consultant, Professor of Physics, North Carolina State of the University of North Carolina at Raleigh). Discussion of "Technical Operations Research Model Experiment Final Report TO-B 62-58". Research Memorandum RM 81-7. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 17 July 1963.

ABSTRACT

The results of Technical Operations Research model experiments with limited strips of contamination and a multi-story windowless building are discussed herein. An estimate is made of the discrepancy between theory and experiment that is attributable to spectral and medium differences. Possible explanations are offered for the dose rate variation and the large difference in the computed and measured dose rates in the basement. Recommendations are made for (a) revising the currently used computational procedures for protection factors, (b) conducting additional experiments, and (c) using the data to verify area factor assignments.

CONTENTS

Appendix M

Discussion of "Technical Operations Research Model Experiment Final Report TO-B 62-58"

I. INTRODUCTION

A. Purpose

One of the major tasks of OCD Project 1115A was to "evaluate new information on shielding for application to the computation of protection factors for surveyed structures." The objectives of this task are several-fold: to determine if existing methods for computing protection factors need modification to agree with new data; to suggest applications of new shielding information to problems confronting the Office of Civil Defense; and to recommend new investigations in areas where gaps exist in current shielding knowledge. The purpose of this appendix is to report the results and conclusions of RTI's study of the "Final Report on the Effect of Limited Strips of Contamination on the Dose Rate in a Multi-story Windowless Building" (Reference 1) by Technical Operations Research (Tech Ops) of Burlington, Massachusetts.

B. Description of Tech Ops Experiments

Tech Ops investigated the effects of limited fields of contamination on the dose rate within multi-story structures. A six-story 36 x 48 x 72 foot high building with basement was simulated by a model structure with a 1/12 scale factor and with the following steel wall-floor thicknesses (in psf): 0-0, 0-20, 20-20, 20-80, and 80-80. Quarter symmetry strips of contamination were formed by closely spaced cobalt-60 point sources near the building and by the pumped source method in outer strips. Dose measurements were made in three horizontal planes above each floor at points in each plane near the corners and at the center of the building.

II. DISCUSSION

A. General

The series of thorough and well-planned experiments reported by Tech Ops in Reference 1 has yielded a wealth of attenuation data. In addition to obtaining basic dose rate data for various experimental configurations, Tech Ops conducted several experiments for calibration and data reduction purposes. These included measurements of source anisotropy, tubing attenuation, ground penetration to the basement area, cobalt-60 buildup factors for a source on the ground, and dose rates in a phantom structure with 0 psf walls and floors. The phantom structure data, after being scaled up and corrected for tubing attenuation, source anisotropy, and improper atmospheric density, agreed well with previously published results. Tech Ops compared their limited strip results with calculations made with the Office of Civil Defense "Guide for Architects and Engineers" (Reference 2), and the National Shelter Survey Computer Program (Refs.3 and 4). In addition, their infinite field data were compared with the predictions of the Office of Civil Defense Engineering Manual, "The Design and Review of Structures for Protection from Fallout Gamma Radiation" (Reference 5). Tech Ops' major conclusions and recommendations were:

1. "The Computer Program is in error for near-field limited strips because no distinction is made between thin- and thick-floor correction factors. Experimental correction factors are presented. More work is recommended on floor-edge scattering and attenuation by floor slabs.
2. Measured and computed infinite-field dose rates are in excellent agreement.
3. A revised procedure for calculating the contribution from far-field limited strips is recommended.
4. Dose rates measured in the basement are higher than predicted. Further investigation is recommended on a full-scale basement."

B. Estimate of Discrepancy Associated with Spectral and Medium Differences

The experiments were conducted with a cobalt-60 source and a steel structure. The computational procedures of the Engineering Manual, Computer Program, and A&E Guide are based on the attenuation of a fission spectrum of gamma rays by a water medium. Barrier factor curves for cobalt-60 gamma rays incident on water and concrete are available in Dr. L. V. Spencer's Monograph (Reference 6). Tech Ops used cobalt-60 data (presumably on concrete) for barrier factors in their Engineering Manual calculations for infinite fields of contamination. It was of interest to estimate the magnitude of the difference in theory and experiment that is attributable to use of fission and water data or cobalt-60 and concrete data for calculations to compare with experiments in which cobalt-60 and steel are used. In general, comparisons of absolute values of dose rates or reduction factors should be more dependent on these differences than ratios of doses such as the fraction of the infinite field dose that is due to various limited fields of contamination.

1. Spectral Differences - The barrier factors associated with the floors $B_o(X_o)$ and the walls $B_w(X_e,H)$ are the dominant attenuation factors.

   a. Floor Barrier Factor - The floor factor $B_o(X_o)$ in the Engineering Manual is equal to L(X) in Spencer's Monograph which contains calculations for cobalt-60 gammas in water and fission gammas in water. Graphs of L(X) versus X in psf are presented in Figure M-1. These curves represent the dose rate in r/hr at various depths in an infinite medium of water due to an infinite plane isotropic source with strength such that the dose rate at 3 ft in air is 1 r/hr.

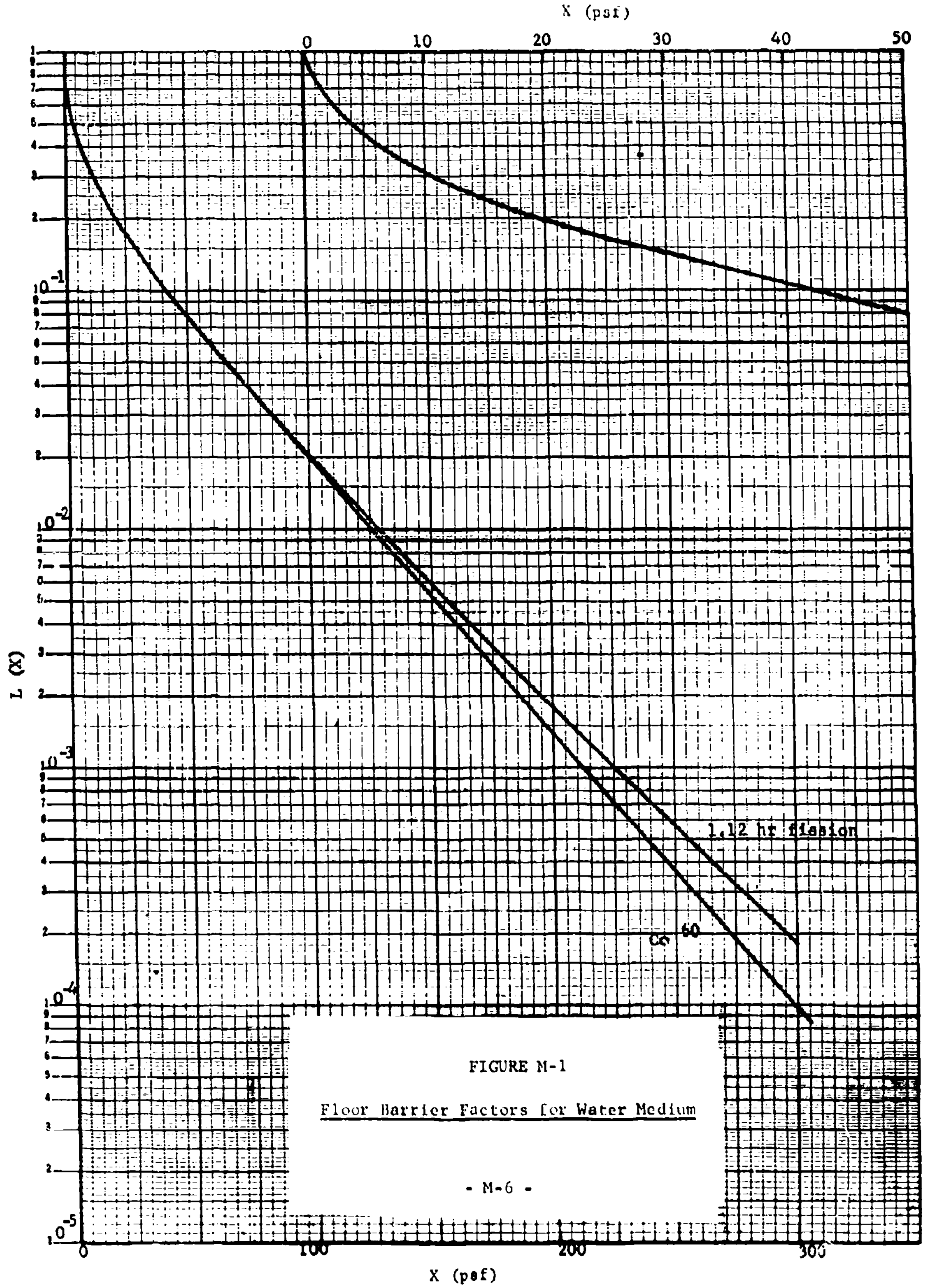


FIGURE M-1

Floor Barrier Factors for Water Medium

It is seen that these curves are indistinguishable for mass thicknesses(X) less than 100 psf. At greater depths the fission spec.rum produces a larger dose rate owing to its higher energy components.

b. Wall Barrier Factor - The dependence of the wall factor $B_w(X_e,H)$ on the gamma energy is very similar to that for $L(X)$. $B_w(X_e,H)$ of the Engineering Manual is derived from the $W(X_e,H)$ curve in Spencer's Monograph, $B_w(X_e,H) \simeq 0.5\ W(X_e,H)$. Tabulated below are values for $W(X,3')$ and $L(X)$ for cobalt-60 ($\sim$ 1.2 Mev) and cesium-137 (0.66 Mev) gammas incident on concrete (Reference 6).

	$W(X,3')$			$L(X)$		
X psf	Cs^{137}	Co^{60}	Ratio $\frac{Co}{Cs}$	Cs^{137}	Co^{60}	Ratio $\frac{Co}{Cs}$
50	.11	.146	1.3	.054	.068	1.3
100	.024	.044	1.8	.0088	.0165	1.9
200	.00086	.0037	4.3	.00026	.0011	4.3
300	.000029	.00030	10.3	.0000072	.000076	10.6

It is seen that for a given mass thickness X, the fractional increase in $W(X,3')$, and hence $B_w(X_e,H)$, when the cesium-137 source is replaced by a cobalt-60 source is essentially the same as the fractional increase in $L(X)$ (compare ratio columns). Consequently, the relative change in both barrier factors, $B_w(X_e,H)$ and $B_o(X_o)$, due to simulating a fission source

with cobalt-60 is negligible for mass thicknesses less than 100 psf, is 20 per cent at 200 psf, and is 50 per cent at 300 psf.

2. Medium Differences - The effect of substituting steel for concrete (for the Engineering Manual - Spencer Monograph calculations) and steel for water (for the A&E Guide and Computer calculations) can be seen from the behavior of the L(X) barrier factor curves in Figure M-2 for a cesium-137 source. The water and concrete data were taken from Spencer's Monograph and the iron results were computed at North Carolina State College by the author. In the range $100 < X < 200$ psf, the factors are in the ratio (water): (concrete): (iron):: 1:0.7:0.5. At X=80 psf, L(X,iron)/L(X,water) is 0.6 and L(X,iron)/L(X,concrete) = 0.75.

3. Combined Spectral and Medium Differences - Figure M-3 shows the variation with energy and medium of the barrier factors at X=80. The point for a fallout spectrum coincides with the cobalt-60 point. Calculations made for a water medium should be reduced by 35 per cent if the medium is steel, and calculations based on concrete data should be reduced by 25 per cent. The corresponding values for X=20 psf are 20 and 15 per cent, respectively.

C. Revision Required in Current Computational Procedures

1. Infinite Field Data

a. Above Ground Floors - The Computer Program calculates the contribution from limited strips of contamination by multiplying the contribution from an infinite field by a correction factor. In order to compare experimental data for limited

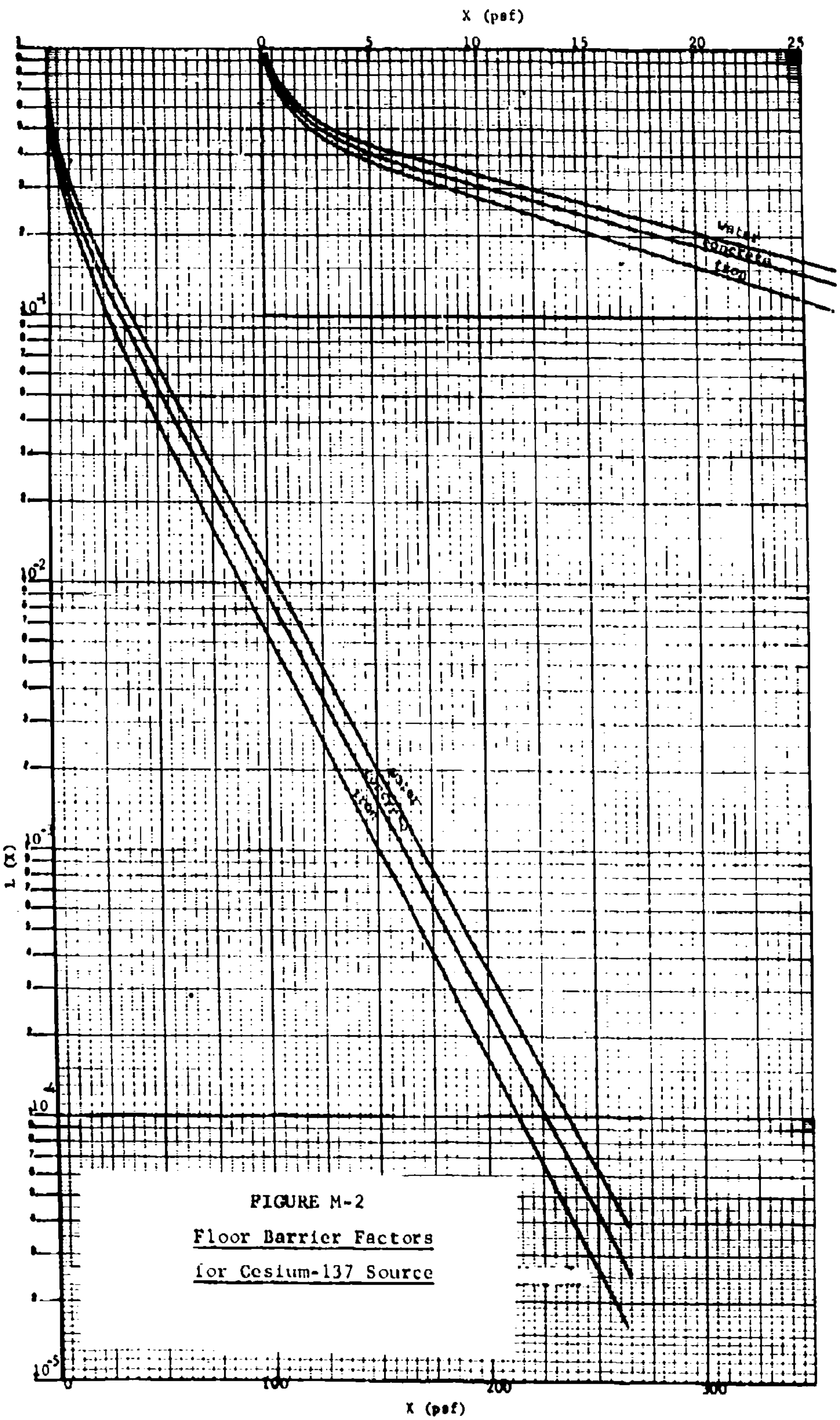


FIGURE M-2

Floor Barrier Factors

for Cesium-137 Source

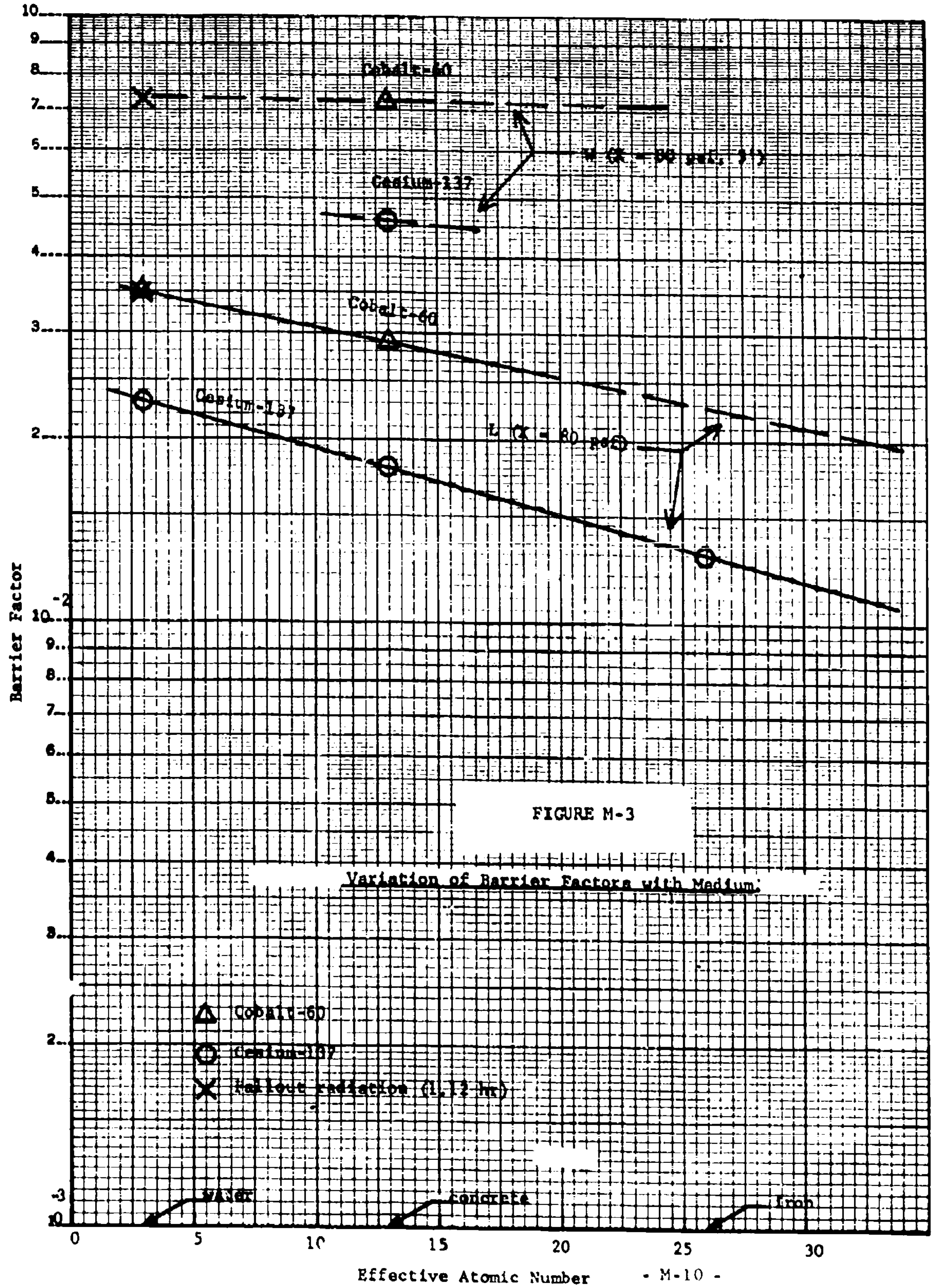


FIGURE M-3

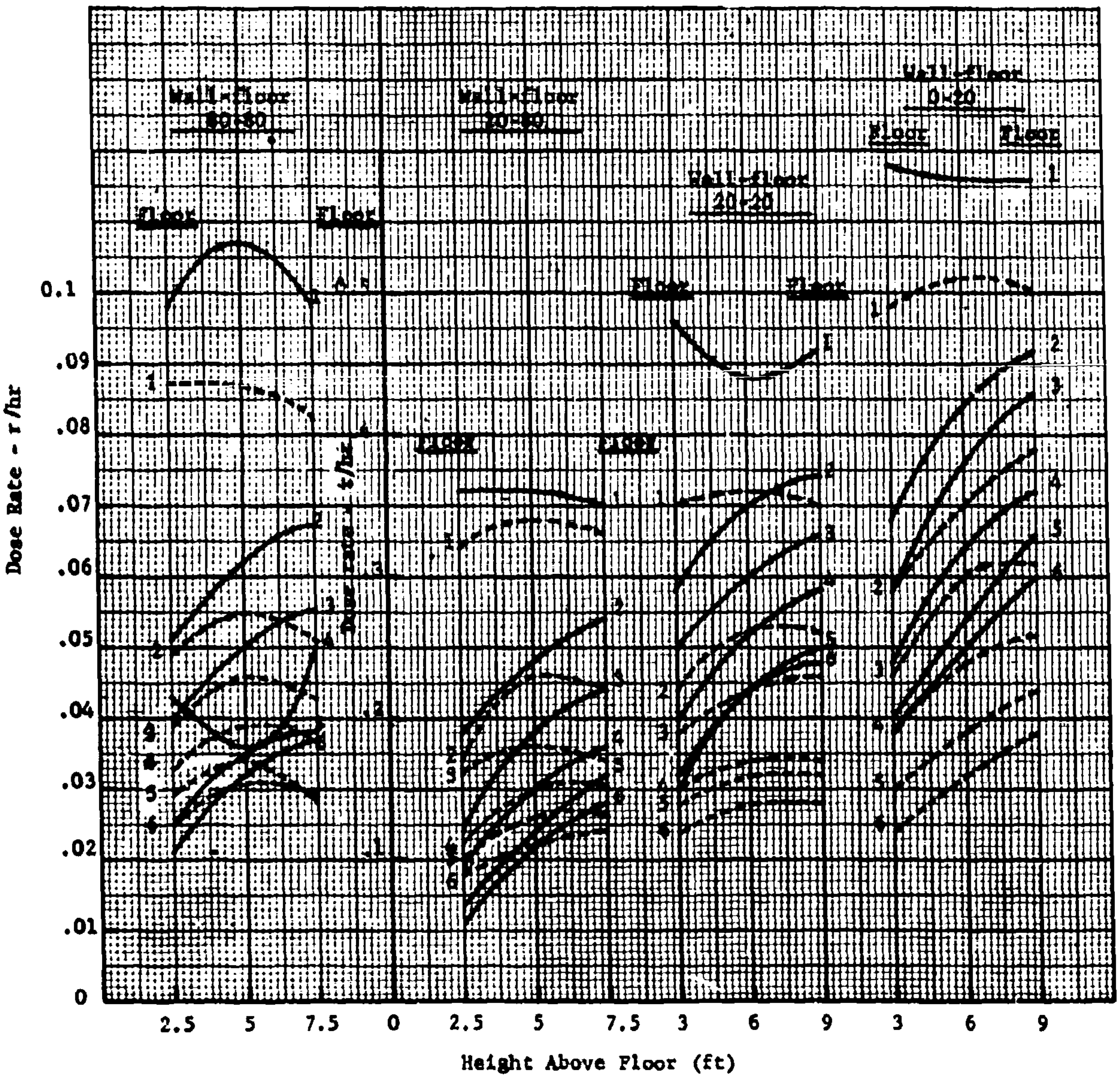
Variation of Barrier Factors with Medium

FIGURE M-4

Tech Ops' Infinite Field Data

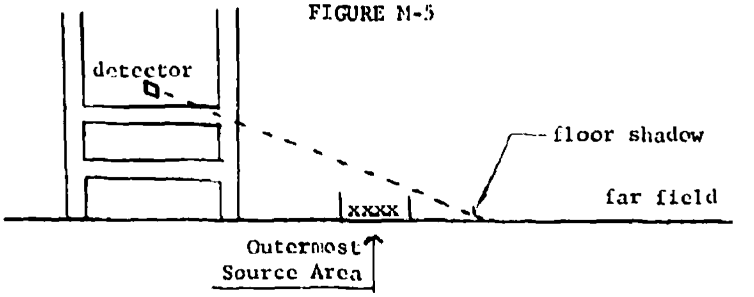
——— Measurement

– – – – – Engineering Manual Calculation



strips with this correction factor, it was necessary for Tech Ops to determine the dose rate from an infinite field. These data are shown in Figure M-4 along with the Engineering Manual results (dotted lines) taken from the Tech Ops' report (Table 14). The dose rate is plotted versus detector height above the floor with floor number as a parameter. (The 2.5' and 5' data on the 4th floor of the 80-80 building are apparently interchanged.) The infinite field data were obtained from the limited strip data by adding a far-field contribution which was estimated by multiplying the contribution from the outermost source area by a factor based on geometry and air attenuation considerations. This technique is precise for the phantom structure (as demonstrated by Tech Ops), approximately correct when the same mass thickness is placed between the detector and outer source ring as between the detector and far field, and can be seriously in error if different mass thicknesses are located between them as shown in Figure M-5. The radiation from the outermost source must

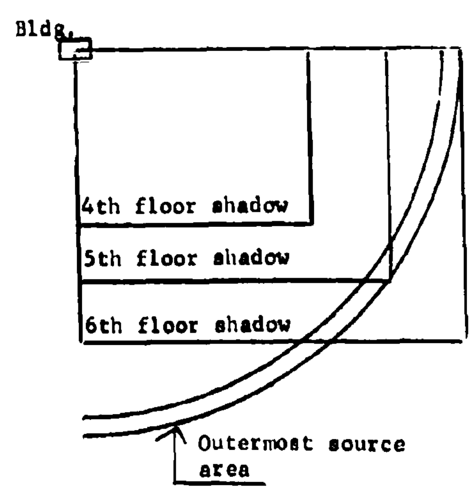
FIGURE M-5



Section of building for which floor shadow extends just beyond outermost source area.

pass through the exterior wall and floor slab, whereas, the far-field radiation passes only through the exterior wall. In this case, the factor previously used to compute the far-field contribution from the outermost source contribution must be multiplied by $1/B_o(X_o)$ to account for the additional floor attenuation. For X_o=80 psf steel floors, $1/B_o(80)$ is approximately 30 (see Figure M-1. Most of the detector points in Tech Ops experiments were located so that this factor $1/B_o(X_o)$ is not required. Figure M-6 shows floor shadows superimposed on

FIGURE M-6



Overlap of floor shadow with outermost source area for 2.5 ft detector location.

the outermost source area for a central point detector located 2.5 ft above the floor. It is seen that radiation from more

than half of the source area must penetrate the floor slab before reaching a detector on the 6th floor. Consequently, the far-field contribution which does not pass predominantly through the slab will be underestimated. The data from the far-corner positions A, C, and D on upper floors are affected similarly. The effect of taking these considerations into account is to raise the experimental (solid) curves for the 5th and 6th floors at the 2.5 ft height. The relative increase in dose rate will be larger for the thicker floors. After this adjustment, it appears that all of the experimental curves will be somewhat above the Engineering Manual calculations, (mostly 10-20 per cent with a minimum and maximum of 0 and 70 per cent, respectively). The same trend is also observed when the experimental data are compared directly with Engineering Manual calculations using the actual dimensions of the scale model (Ref. 7 and App. L). This gap will widen approximately 25 per cent for 80 psf walls when steel data are substituted for concrete data in the calculations. These results indicate that calculations made with the Engineering Manual method and steel data are not conservative but predict dose rate values that are somewhat lower than experimental values. However, in practice, this difference is partially compensated for when the water-data curves in the Engineering Manual are used to predict dose rates in concrete buildings. Consequently, no change is recommended in the computational procedure of the Engineering Manual for above ground

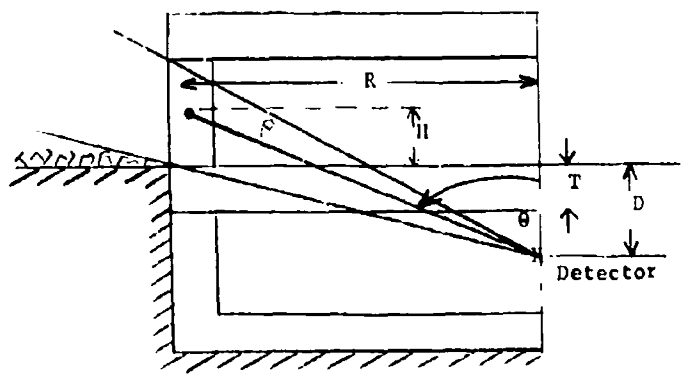
floors and infinite fields of contamination. It is suggested that the accuracy of the procedure be re-examined when more full-scale data become available. Existing full-scale experimental data (Reference 8) for a concrete block-house agree within ±15% of Spencer's theory (Reference 6).

It would be interesting to have the phantom structure data and Engineering Manual calculations for 0-0 psf walls and floors presented in Table 14 of Tech Ops' report along with the other infinite field data. This would facilitate an evaluation of the directional response function for the direct radiation $G_d(\omega,H)$.

b. Basement Area - The experimental dose rate values from an infinite source field at a point 6 ft below the basement ceiling are 1.5 to 4 times as large as the computed values even after correction for floor-edge scattering and ground penetration. Moreover, the dose rate first increases with depth, then decreases, whereas computations always predict a decrease in dose rate with depth. These disagreements are sufficiently large to cast doubt on the accuracy of the factors used in calculating basement dose rates. There is some evidence that full-scale basement measurements in a block-house experiment (Reference 9, page III-117) also give dose rates that are 2-3 times larger than Engineering Manual results. It is therefore recommended that the Engineering Manual factors be revised to agree with experimental results. In view of the difficulty in properly scaling up model data to full-scale, RTI supports Tech Ops recommendations that full-scale basement measurements be made for comparison purposes. Possible explanations for the breakdown in the Engineering Manual procedure are offered below.

(1) Error in Absolute Magnitude - The skyshine barrier factor $B_o'(X_o')$ in the Engineering Manual for the basement ceiling attenuation is probably too small. $B_o'(X_o')$ is obtained by integrating slant penetration data over the entire backward hemisphere (Reference 9, page II-76, and Reference 6, page 24). This procedure includes the grazing contribution which is greatly attenuated by the initial layers of material. It is seen in Figure M-7 below that radiation reaches the detector from a limited solid angle. An estimate can be made for the barrier factor as follows: assume that the predominant radiation is incident on the floor at an angle $\theta = \tan^{-1} R/(H+D) = 56^{o}$ with an average energy equal to that of cesium-137 (0.66 Mev). The attenuation for this incident obliquity $\cos \theta = 0.56$ and $X = 80$ psf is $\cos \theta \ s(X, \cos \theta) = 0.046$ (Reference 6, Figure B6). This factor is approximately 3.7 times larger than $B_o'(X_o' = 80) = 0.017$.

FIGURE M-7



Section of basement (R=18', T=2', D=6', H=6' midwall height).

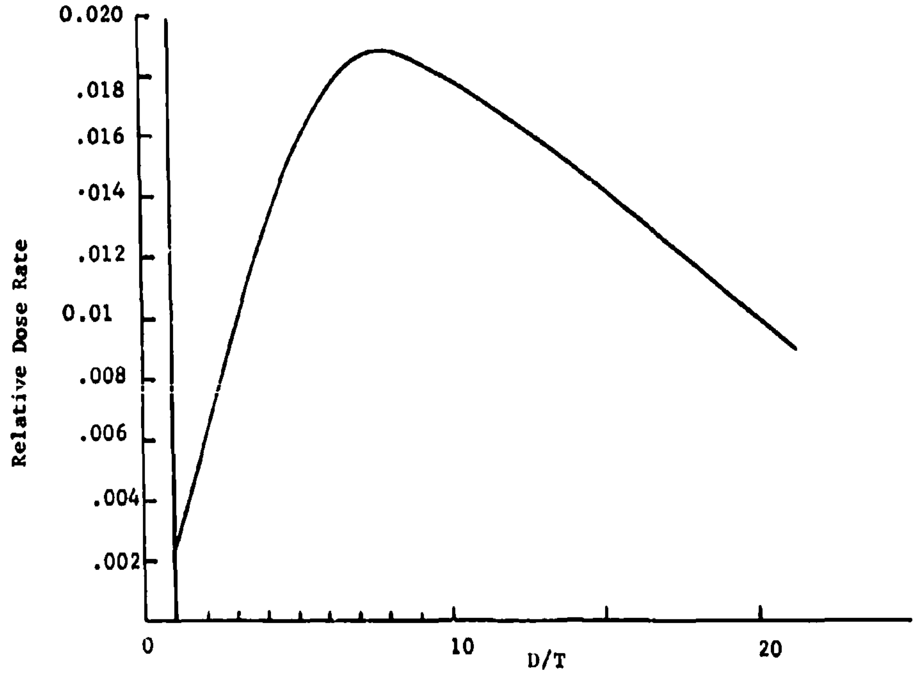
(2) Dose Rate Variation with Depth - The initial increase and then decrease in dose rate with increasing depth is a consequence of the competing effects of solid angle considerations (inverse-distance-squared attenuation) and change in slant penetration through the floor slab. Assume for simplicity that all photons emerging from the wall can be represented as a monoenergetic source at midwall height H = 6'. The dose rate at a depth D due to the uncollided gammas is proportional to $[\exp - \mu T \sec \theta]/\rho^2$. A plot of this function (Figure M-8) as D varies from T (just beneath the slab) to 20 T displays the maximum observed in the experiments. The proper incident angular energy spectrum and multiple scattering in the floor and ceiling must be included to obtain accurate absolute barrier factors.

2. Limited Strip Data

Tech Ops found that for thick floors, separate correction factors for first- and upper-floor locations are needed in order to correct infinite field computations for limited fields of contamination; whereas, the Computer Program uses a single factor for all locations. These findings support RTI's previous recommendation (Reference 10) that the computational procedure of the Computer Program be revised for above ground floors. The procedure suggested by Tech Ops for near-field and far-field strips appears adequate to predict their experimental results and represents an improvement on the existing computer method. The Tech Ops procedure uses revised M_L tables with entries deduced from measurements. The tables are therefore applicable for

FIGURE M-8

Variation of Dose Rate with Depth in Basement



20 and 80 psf floors. In order to use these data for other thicknesses, Tech Ops suggests that all floors with mass thicknesses $X_f \leq 40$ psf be assigned an M_L value based on 20 psf floor data and all thick floors with $X_f \geq 40$ psf be calculated with 80 psf data. For example, for a limited strip with width W_c twice the detector height h and 20 psf walls, the multiplicative correction factor M_L for an upper floor with $X_f = 35$ psf is 0.10, whereas, it jumps down to 0.028 for $X_f = 45$ psf. The factor M_L is also somewhat dependent on wall mass thickness. For the above mentioned strip and thick floors, M_L is 0.028 for 20 psf walls and 0.037 for 80 psf walls. In order to make full use of mass thickness data collected in the survey, one would need M_L tables which could be entered in 10 psf increments. Since interpolation and extrapolation of 20 and 80 psf data to all other thicknesses encountered in practice may be unreliable, and for other reasons cited in Reference 10, RTI recommends that the Engineering Manual method be incorporated in the next revision of the Computer Program. It is also recommended that Tech Ops limited strip data such as in their Figures 13, 15, and 17 be compared with Engineering Manual calculations. This comparison is of great importance because the chief dose rate contribution in buildings of interest is from limited strips.

D. Other Applications of Data

An objective of the National Fallout Survey is the determination of the number of spaces in each building. This calculation requires the use of area factors which represent the fraction of the total floor area that has an acceptable protection factor. The area factor accounts for the variation in

radiation level as one goes from the center of the shelter to the periphery. Tech Ops measured this variation for the above ground floors and presented their results in Table 42 as ratios to the center 3 ft position. These data will enable verification of calculated dose rate variations which are used in assigning area factors.

E. Recommendations for New Investigations

In addition to suggestions presented above, the following recommendations are made.

1. Floor Barrier Factor

Tech Ops noted a dip (Reference 1, page 35) in the dose-rate curves for limited strips with widths varying in the vicinity of the floor shadows. This dip decreased with increasing wall thickness and with detector height above floor level. The Computer Program does not predict such behavior, and Engineering Manual calculations are not available for comparison. This behavior may be an indication that one cannot neglect the dependence of the floor barrier factor on the wall mass thickness previously penetrated by the radiation and its angle of incidence on the floor slab. It is recommended that an attempt be made to measure floor barrier factors for comparison with theoretical predictions for various wall mass thicknesses.

2. Basement Area Factors

In general, the dose rate is higher in the center of a basement than at the perimeter. However, an area factor of unity is assigned to basements by the Phase 2 instructions (Reference 11, page DCFI-30).

If a central region is excluded by reducing the area factor, it may be possible to elevate a basement from a lower protection factor category to a higher one. To verify whether or not this is feasible, it is recommended that dose rates be measured also at off-center locations in future basement experiments.

3. General

It is recommended that, wherever possible, the separate basic factors used in protection factor calculations be individually investigated experimentally. This approach is perhaps more time consuming but has the advantage of pointing out directly the concepts that need revision.

REFERENCES

1. John F. Batter, Albert W. Starbird and Nancy-Ruth York. Final Report, the Effect of Limited Strips of Contamination on the Dose Rate in a Multi-story Windowless Building. Report No. TO-B 62-58. Burlington, Mass.: Technical Operations, Inc., August 1962.

2. Office of Civil Defense. Fallout Shelter Surveys: Guide for Architects and Engineers. Washington: Office of Civil Defense, Department of Defense, December 1961.

3. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for the National Fallout Shelter Survey. National Bureau of Standards Report No. 7539. Washington: U. S. Department of Commerce, July 1962.

4. National Bureau of Standards. Description of Computer Program for National Fallout Shelter Survey. National Bureau of Standards Report 7826. Washington: U. S. Department of Commerce, 15 March 1963.

5. Office of Civil Defense. Design and Review of Structures for Protection from Fallout Gamma Radiation. (Engineering Manual). Rev. ed.; Washington: Office of Civil Defense, Department of Defense, 1 October 1961.

6. L. V. Spencer. Structure Shielding Against Fallout Radiation from Nuclear Weapons. National Bureau of Standards Monograph 42. Washington: U. S. Department of Commerce, 1 June 1962.

7. W. O. Doggett. Evaluation of Technical Operations, Inc., Model Experiment Report TO-B 62-26. Research Memorandum RM 81-3. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 5 November 1962.

8. M. A. Schmoke, R. E. Rexroad and Hans J. Tiller. "Attenuation of Radiation from Distributed Gamma Sources as a Function of Wall Thickness for a Concrete Blockhouse." Transactions of the American Nuclear Society, Vol. 6, No. 1, (June 17-19, 1963) 186-187.

9. Kansas State University, Department of Nuclear Engineering. Proceedings and Final Report of the 1962 Summer Institute on Fundamental Radiation Shielding Problems. Manhattan, Kansas: Kansas State University, November 1962.

10. E. L. Hill, R. O. Lyday, W. K. Grogan, H. G. Norment, and W. O. Doggett. Interim Recommended Modifications to NBS-NFSS Computer Program. Research Memorandum RM 81-5. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 19 April 1963.

11. Office of the Chief of Engineers. Fallout Shelter Survey Instructions - Phase 2. Washington: Department of the Army, Office of the Chief of Engineers, 21 March 1962.

Appendix N

Discussion of "Technical Operations Research Model Experiment on Interior Partitions TO-B 63-6"

This Appendix was originally submitted to OCD as Research Memorandum RM 81-8,* except for minor editorial changes.

* W. O. Doggett (Consultant, Professor of Physics, North Carolina State of the University of North Carolina at Raleigh). Discussion of "Technical Operations Research Model Experiment on Interior Partitions TO-B 63-6". Research Memorandum RM 81-8. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 30 July 1963.

ABSTRACT

Presented herein are recommendations for some revisions in the NBS-NFSS Computer Program and A & E Guide, and suggestions for additional model experiments resulting from a review of the Technical Operations Research model experiments on interior partitions reported in TO-B 63-6.

CONTENTS

Discussion of "Technical Operations Research Model Experiment on Interior Partitions TO-B 63-6"

I. INTRODUCTION

OCD Project 1115A called for an evaluation of new information on shielding. Reported in this appendix are RTI's comments and recommendations on the Technical Operations Research report, "The Effect of Interior Partitions on the Dose Rate in a Multistory Windowless Building" (Reference 1). Tech Ops experimentally determined the dose rate in steel models with box, corridor, and compartment partition arrangements using cobalt-60 gamma radiation. They found excellent agreement between their measurements and calculations based on the OCD Engineering Manual (Reference 2).

II. DISCUSSION

A. General. The comments in Section II. B. of Appendix M, originally submitted to OCD as RTI RM 81-7 (Reference 3), on the medium and spectral differences in the experimental and computational models are applicable to this series of experiments. Cobalt-60 almost precisely simulates a 1.12 hr. fission spectrum for mass thicknesses less than 100 psf. Barrier factors for a water medium such as presented in the Engineering Manual should be reduced by 20 percent when applied to a steel medium with 20 psf mass thickness. This value increases to approximately 35 percent for an 80 psf thickness. One should expect, therefore, that the dose rate measurements would fall below the magnitudes predicted by the Engineering Manual. However, Tech Ops' data lie within 15 percent of the calculations. These results indicate that the measured attenuation for interior partitions is somewhat less than that predicted, or the partition mass thickness used in the experiment is less than that assumed in the calculations. The 60 psf partitions were comprised of 3 thicknesses of 1/2 inch steel plate. According to Reference 4 (Equation 22.1 and Table 22.1), this corresponds to the effective mass thickness

$$
\begin{aligned}
X &= 2 \langle Z/A \rangle \rho \Delta \\
&= 0.931 \times 480 \times 3 \times (1/2) \times (1/12) \\
&= 56 \text{ psf}
\end{aligned}
$$

which is about 7 percent less than the nominal value of 60 psf. This difference accounts for about 10 percent difference in dose rates.

B. Revisions Recommended in Protection Factor Computational Procedure.

1. General

Tech Ops makes the following conclusions:

"For the interior partition geometries investigated in this study, a good estimate of the effects of interior partitions may be made by the following:

a. Box and Corridor Geometrics. Multiply the dose rate computed in the center of the structure without interior partitions by the barrier attenuation factor (Engineering Manual, Chart 1, Case 2) for a mass thickness equal to the interior wall thickness.

b. Compartment Geometries. Multiply the dose rate computed in the center of the structure without interior partitions by the barrier factor for a mass thickness equal to the corridor walls plus one-half the compartment wall mass thickness."

The effect of interior partitions can be readily included in protection factor computations using the above prescription.

2. A & E Guide

It is recommended that revised editions of the Guide for Architects and Engineers (Reference 5) include the instruction: "The proper interior mass thickness X_i depends on the partition configuration. For box and corridor geometries, use a mass thickness equal to the interior wall thickness. For compartment geometries with corridor mass thickness X_c and cross partition

thickness X_p, use $X_i = X_c + \frac{1}{2} X_p$."

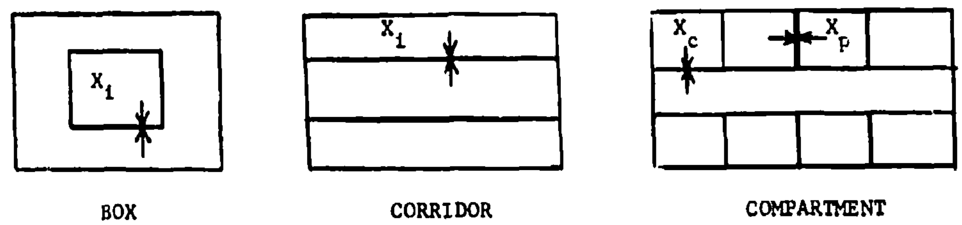


FIGURE N-1

Plan View Showing Partitions

No additional charts will be required, because the simplified method of the A & E Guide treats interior partitions as if they are located at the exterior wall, $X_w = X_i + X_e$.

3. <u>NBS - National Fallout Shelter Survey Computer Program</u>

Tech Ops data show that the Engineering Manual method of handling interior partitions with azimuthal sectors is satisfactory. RTI has recommended revisions to the NBS-NFSS Computer Program which essentially follow the Engineering Manual method, yet require only the Phase 2 Survey data (Reference 6). Since these data are collected on a wall-by-wall basis and are not sufficiently detailed to permit the use of azimuthal sectors in calculating attenuation due to interior partitions, the azimuthal sectors that are inherent in the recommended changes are those defined by the exterior wall intersections. Consequently, the revised Computer Program will not treat interior partitions with the Engineering Manual method. It is therefore necessary to program instructions so that the Computer Program can interpret interior partition data. Corridor and cross partitions, as well as their average spacing and general pattern, are

entered in the Phase 2 collection forms (Reference 7, page DCFI-24). The influence of the spacing of cross partitions in compartment geometry on dose rates was not investigated by Tech Ops. However, an approximate prescription can be formulated as follows: The spacing used in the experiment was such that if all cross partitions on one side of the corridor were rotated 90° and placed end-to-end, they would form a corridor type partition that would extend practically the entire length of the building. In other words, the smeared mass thickness of the cross partitions is nearly equal to their actual mass thickness. Sufficient data are available for the computer to calculate smeared mass thicknesses. It is therefore recommended that:

a. Interior partitions between a detector and wall which have box or corridor geometries be assigned a mass thickness equal to the sum of the interior wall thicknesses.

b. Cross interior partitions be assigned a mass thickness equal to one-half the smeared mass thickness.

c. The total interior mass thickness be set equal to the sum of those calculated in a and b.

Consider, for example, the contribution from side C of a building of type 1 (Reference 7, page DCFI-25) shown in Figure N-2

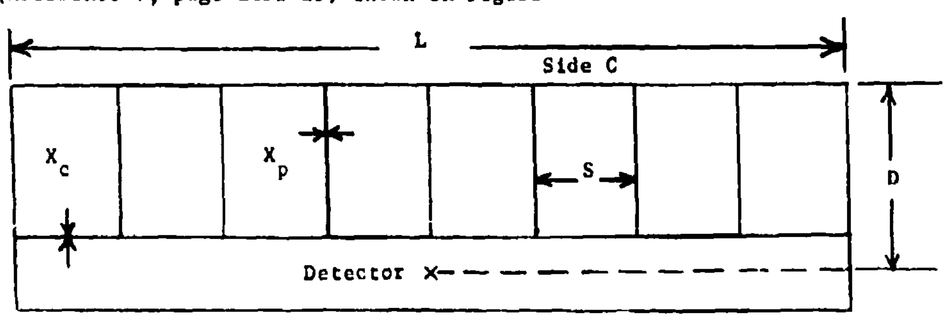


FIGURE N-2
Plan of Building With 7 Cross Partitions
X_c = 40 psf, X_p = 20 psf, L = 80', D = 20', S = 10'

The smeared thickness of one cross partition is X_p D/L, and that for $(\frac{L}{S} - 1)$ partitions is:

$$X_p\Big)_{\text{smeared}} = \left[\frac{L}{S} - 1\right] X_p \frac{D}{L}$$

$$= \left[\frac{80}{10} - 1\right] (20) \left[\frac{20}{80}\right]$$

$$= 35 \text{ psf}$$

The total interior mass thickness for side C is:

$$X_i = X_c + \tfrac{1}{2} X_p\Big)_{\text{smeared}}$$

$$= 40 + \tfrac{1}{2} (35)$$

$$= 57.5 \text{ psf}$$

The same value can be used for the contribution from the left and right ends of the building in Figure N-2.

C. Additional Experiments Recommended.

1. Effect of Cross Partition Spacing. The recommendation in II. B. 3. above is based on the assumption that the smeared mass of cross partitions is the only parameter needed to estimate their effectiveness. This means that a building with N interior partitions with mass thickness X_p will give the same protection as another building with 2N partitions with thickness $X_p/2$. This concept is now employed for corridor partitions in the Engineering Manual. However, because the recommendation to use one-half the cross partition smeared mass thickness is a departure from the Engineering Manual method, it is advisable to check its validity experimentally. It is suggested that an experiment with compartmental partitions be conducted with 6 cross partitions of 20 psf thickness and 7" spacing. If the above assumption is correct, the results should be nearly the same as the experiment with 3 partitions of 40 psf thickness and 12" spacing (Reference 1, Figure 13).

2. Effect of X_w on B_w (X_i, 3'). A basic assumption in the Engineering Manual in calculating the attenuation by interior partitions is that the angular energy distribution incident on the partitions is the same as that incident on the exterior wall at ground level. Thus, the combined barrier factor for a first floor wall and partition is $B_w(X_e,3') \times B_w(X_i,3')$. The A & E Guide assumes that the partition is adjacent to the exterior wall and uses $B_w(X_e + X_i,3')$. These two expressions can be equivalent only for an exponential variation of the barrier factor with mass thickness. Reference to Chart 1, Case 2, of the Engineering Manual for B_w shows that its variation is simple exponential up to X_w = 100 psf. If spreading of the radiation from the wall to the partition could be neglected, one might therefore expect that either expression above would give satisfactory results for $X_i + X_e < 100$ psf. For experiments with $X_i + X_e > 100$ psf, where curvature in the B_w curve sets in, one might suspect that the single factor B_w (X_i, 3') for partitions may begin to break down unless the effect of the exterior wall on the incoming radiation is taken into account. In the Tech Ops experiments, the exterior mass thickness was 20 psf and the interior mass thickness ranged up to 60 psf. The majority of the radiation penetrating 20 psf walls is uncollided and hence behaves very much like that incident on the walls. If the walls are increased to 80 psf, most of the radiation that passes through the walls is scattered. It is therefore recommended that the interior barrier factor be measured for box type interior partitions of thicknesses 20, 40, 60 psf in a building with 80 psf exterior walls to determine the influence of the wall on the partition barrier factor. The barrier factor can be determined by comparing the experimental results with those previously measured without partitions. Although the dose rates will be very low, good data should be obtainable on the lower floors.

D. Use of Data for Estimating Area Factors.

The excellent agreement of Tech Ops' results with the Engineering Manual method justifies the use of the manual for calculating the variation of dose rate throughout a shelter, and, hence, for estimating area factors (defined in Reference 7, page DCFI-30).

REFERENCES

1. Albert W. Starbird, Joseph D. Velletri, Robert L. MacNeil, and John F. Batter. The Effect of Interior Partitions on the Dose Rate in a Multistory Windowless Building. Report No. TO-B 63-6. Burlington, Massachusetts: Technical Operations Research, 31 January 1963.

2. Office of Civil Defense. Design and Review of Structures for Protection from Fallout Gamma Radiation. (Engineering Manual). Rev. ed.; Washington: Office of Civil Defense, Department of Defense, 1 October 1961.

3. W. O. Doggett. Discussion of Technical Operations Research Model Experiment Final Report TO-B 62-58. Research Memorandum RM-81-7. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 17 July 1963.

4. L. V. Spencer. Structure Shielding Against Fallout Radiation from Nuclear Weapons. National Bureau of Standards Monograph 42. Washington: U. S. Department of Commerce, 1 June 1962.

5. Office of Civil Defense. Fallout Shelter Surveys: Guide for Architects and Engineers. NP-10-2. Washington: Office of Civil Defense, Department of Defense, December 1961.

6. E. L. Hill, R. O. Lyday, W. K. Grogan, H. G. Normont, and W. O. Doggett. Interim Recommended Modifications to NBS-NFSS Computer Program. Research Memorandum RM-81-5. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 19 April 1963.

7. Fallout Shelter Survey Instructions - Phase 2. Washington: Department of the Army, Office of the Chief of Engineers, 21 March 1962.

Appendix O

Conclusions and Recommendations of "Technical Operations Research"

The conclusions and recommendations made by Technical Operations Research in References 1, 2, 3, 4, and 5 and concurred with by RTI (see Part I, Chapter 6) are consolidated in this appendix. They all result from measurements taken at the OCD-Tech Ops modeling facility.

1. The method of correction for limited fields of contamination as presently used in the National Shelter Survey Computer Program (NSSCP) can lead to considerable error in the case of thick floors. The NSSCP presents a single multiplicative correction factor for all height positions. Experimental values indicate that when the floor thickness is not great ($X_f \leq 40$ psf) a single correction factor is adequate for all floor locations. However, where floor thicknesses exceed 40 psf, one correction factor applies for first-floor locations and a separate factor is required for upper-floor locations.
2. The multiplicative correction factors as presented in Table 6 of the NSSCP show fair agreement with experimental values. Presently used and experimentally obtained values are given in Tables 40 and 41 of References 1 and 2.
3. The dose rate from limited strips of contamination ($W_c/h \leq 10$, $W_c \leq 300$ feet) at locations and heights other than that at the center of the structure at a 3-foot height may be estimated within 25 percent accuracy, as ratios of the center position dose rate. These dose ratios are given in Table 42 of References 1 and 2.
4. The present method used in the NSSCP to compute the effect of far-field limited strips of contamination is to compute a factor and multiply this factor times the infinite-field dosage. This factor, the ratio of the dose expected from the limited field to that expected from an infinite field, is computed from

Appendix O

Conclusions and Recommendations of "Technical Operations Research"

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4. The present method used in the NSSCP to compute the effect of far-field limited strips of contamination is to compute a factor and multiply this factor times the infinite-field dosage. This factor, the ratio of the dose expected from the limited field to that expected from an infinite field, is computed from

air-attenuation functions. The experimentally measured values in general agree within 30 percent of those computed. Better agreement between theory and experiment may be obtained, however, if the computation is performed in two steps. These are: (1) compute the effect of near-field contamination ($W_c/h \leq 10$, $W_c \leq 300$ feet) using the methods mentioned above and (2) add to this the effect of contamination existing beyond $W_c/h = 10$ or $W_c = 300$ feet, computing this effect as before, as quoted in References 1 and 2.

5. The agreement between experimentally measured values of infinite-field dose rate and those computed using the methods of the "Fallout Shelter Surveys: Guide for Architects and Engineers" (Reference 6), "Design and Review of Structures for Protection from Fallout Gamma Radiation" (Reference 7), and "Description of Computer Program for National Fallout Shelter Survey" (Reference 8) is excellent.

6. The data obtained from measurements of the dose rate at a distance corresponding to 6 feet below ground level were in general somewhat higher than those predicted by the methods of References 6, 7, and 8. (These are the references listed in 5 above.) This discrepancy increased slightly with increasing depth.

7. The fraction of infinite-field dose rate in basement locations obtained from limited strips of contamination fell on a common curve for all detector depths within approximately 10 percent. The mean values as obtained experimentally in each of the four structures are presented in Table 43 of References 1 and 2.

8. Excellent agreement (within 5 percent) is shown between the dose rate obtained from modeling technique on a phantom structure (no building present) and those previously obtained in similar full-scale geometry by Rexroad (Reference 9).

9. Since floor thickness plays a critical role in the dose obtained from limited strips of contamination, the present series of experiments should be extended to cover the cases of: 0 psf walls and 80 psf floors and 80 psf walls and 20 psf floors

10. Since the agreement between infinite field values of experimental and theoretical data obtained in basement regions is poor, further experiments on both model and full-scale structures should be carried out.

11. The effect of floor-edge scattering (radiation scattering from the edge of a thick floor to a detector) should be thoroughly investigated and analytical methods should be developed to compute this radiation component.

12. The relative agreement between experimentally measured values of infinite field dose rate and those computed using the methods of the Engineering Manual entitled "Design and Review of Structures for Protection from Fallout Gamma Radiation" is excellent for the three (interior partition) configurations investigated

   a. Box partitions The absolute agreement between calculated (Engineering Manual) and experimental values for the center position is excellent for the 0 psf interior partition structure, while for the 20, 40, and 60 psf interior partition buildings, the Engineering Manual consistently underestimates the experimental results by 8, 10, and 15 percent, respectively Agreement at the corner position is within 5 percent.

   b. Corridor partitions Agreement between calculated and experimental values for the center and corner positions is within 7 percent for all corridor wall mass thicknesses investigated Agreement between calculated and experimental values for detectors located inside the corridor at the off-center positions is within 8 percent over all stories

   c. Compartment partitions Agreement between calculated and experimental values for the center and corner positions is excellent. Calculated dose rates

were between 10 and 15 percent higher than experimental dose rates for detector locations at the off-center positions inside the corridor.

13. For the interior partition geometries investigated in this study, a good estimate of the effects of interior partitions may be made by the following:

a <u>Box and corridor geometries</u>. Multiply the dose rate computed in the center of the structure without interior partitions by the barrier attenuation factor (Engineering Manual, Chart 1, Case 2) for a mass thickness equal to the interior wall thickness.

b <u>Compartment geometries</u>. Multiply the dose rate computed in the center of the structure without interior partitions by the barrier factor for a mass thickness equal to the corridor walls plus one-half the compartment wall mass thickness.

14. Dose rates at corner positions for buildings with interior partitions of wall mass thicknesses less than 40 psf are about 10 percent less than those without partitions and 20 percent less for interior partitions of thicknesses greater than 40 psf

15. The fraction of infinite field dose obtained from limited rectangular fields of contamination in a structure with interior partitions of thickness several times greater than the exterior walls is identical to that obtained in a similar structure without interior partitions times the barrier effect introduced by the partitions.

16 It is recommended that a survey of existing buildings be undertaken to determine if the mass thickness and interior partition configurations selected for this study are typical of those to be found in real structures. If interior partition configurations are significantly different from those tested, further evaluation of the Engineering Manual is required.

17. Ceiling-shine radiation, like skyshine radiation, represents approximately 10 percent of the dose rate received by a detector 3 feet above an infinite contaminated plane if the ceiling is of infinite size and thickness, and is parallel to the contaminated plane above the detector.

18. Fair agreement exists between calculated ceiling shine based upon Monte Carlo albedo coefficients and that determined by experiment.

19. Ceilings 10 psf, 20 psf, and 40 psf thick reflect approximately 75 percent, 90 percent and 100 percent, respectively, of that which would be reflected by a ceiling of infinite thickness.

20. An adequate and simplified ceiling shine calculational method has been developed which is cast in the form of procedures presently used in the OCD Engineering Manual.

21. It is recommended that a method of calculation of the dose that would be received inside a structure from radiation reflected from the ceiling be inserted in the present OCD Engineering Manual.

REFERENCES

1. John F. Batter, Albert W. Starbird, and Nancy-Ruth York. Final Report - The Effect of Limited Strips of Contamination on the Dose Rate in a Multistory Windowless Building. Report No. TO-B 62-58. Burlington, Massachusetts: Technical Operations, Inc., August 1962.

2. Albert W. Starbird and John F. Batter. "The Effect of Limited Strips of Contamination on the Dose Rate in a Multistory Windowless Building," Transactions of the American Nuclear Society, Volume 6, No. 1 (1963), 187.

3. Albert W. Starbird, Joseph D. Velletri, Robert L. MacNeil, and John F. Batter. The Effect of Interior Partitions on the Dose Rate in a Multistory Windowless Building. Report No. TO-B 63-6. Burlington, Massachusetts: Technical Operations Research, 31 January 1963.

4. Joseph D. Velletri. "The Effect of Interior Partitions on Dose Rate from a Simulated Fallout Field," Transactions of the American Nuclear Society, Volume 6, No. 1 (1963), 188.

5. John F. Batter and Joseph D. Velletri. The Effect of Radiation Reflected from the Ceiling on the Dose Rate Within Structures. Report No. TO-B 63-25. Burlington, Massachusetts: Technical Operations Research, April 1963.

6. Office of Civil Defense. Fallout Shelter Surveys: Guide for Architects and Engineers. Washington: Office of Civil Defense, Department of Defense, December 1961.

7. Office of Civil Defense. Design and Review of Structures for Protection from Fallout Gamma Radiation. (Engineering Manual). Revised Edition; Washington: Office of Civil Defense, Department of Defense, 1 October 1961.

8. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for the National Fallout Shelter Survey. National Bureau of Standards Report No. 7539. Washington: U. S. Department of Commerce, July 1962.

9. R. E. Rexroad and M. A. Schmoke. Scattered Radiation and Far-Field Dose Rates from Distributed Cobalt-60 and Cs-137 Sources. Report No. NDL-TR-2. Edgewood, Maryland: Nuclear Defense Laboratory, Army Chemical Center, September 1960.

Appendix P

Recommended NBS-NFSS Computer Program Modifications

This Appendix was originally submitted to OCD as Research Memorandum RM 81-5,* except for minor editorial changes

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* E. L. Hill, R. O. Lyday, W. K. Grogan, H. G. Norment and W. O. Doggett. Interim Recommended Modifications to NBS-NFSS Computer Program. Research Memorandum RM 81-5. Durham, North Carolina: Operations Research Division, Research Triangle Institute, 5 November 1962.

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Appendix P

Recommended NBS-NFSS Computer Program Modifications

I. INTRODUCTION

This appendix contains recommendations of the Research Triangle Institute for modifying the existing NBS-NFSS Computer Program (Reference 1) used to compute building protection factors (PF). These recommendations are summarized in Part I, Chapter 7.

The procedures used in the present program are based on the Guide for Architects and Engineers (Reference 2) which gives very conservative building PF's. It is generally concluded that the Engineering Manual method (Reference 3) of calculating PF's gives more accurate results; therefore, the recommended changes are those which bring the NBS-NFSS Computer Program nearer to the Engineering Manual method.

The proposed recommendations involve changes in the computational procedures for the contributions from the roof, exposed basement walls, areaways, and the ground contribution to upper stories. Included as a part of these recommendations is a procedure for considering the contribution from limited planes of contamination and for determining the effective mass thickness of partitions reported in Phase 2. Functional equations, tables representing Engineering Manual charts, the detailed steps necessary to make hand calculations compatible with machine computations, and numerical examples accompany these recommendations.

These recommendations are based on the findings of categorization (see Part I, Chapter 3), the analysis of the 33 sample buildings (see Part I, Chapter 4 and Reference 4), and the review of shielding research (see Part I, Chapter 6).

II. RECOMMENDATIONS

A. Basement Exposure

1. Present Method

For basements with partially exposed walls the present method of calculating PF's is that found in the AE Guide (see Reference 2). Necessary inputs are mass thicknesses of the partitions, exterior walls, and first floor; width and length of the building; fraction of apertures in the basement and first story walls; and the fraction of basement wall exposed. The Reduction Factor (RF) or total contribution is found by adding the "ground contribution - below ground areas" from Table 4 (Reference 1) to the "ground contribution - above ground areas" which is found by multiplying a Table 3 (Reference 1) value by the fraction of basement wall exposed. When apertures are considered, this equation is (using present computer program tables in Reference 1 and symbols defined in Reference 3):

$$RF = \left[\text{Table 4 Value}\right] \; B_o' + \text{Exposure} \left[\left[\text{Table 3 Value } (X_o + X_i)\right] \times \left[1 - A_p\right] + \left[\text{Table 3 Value } (X_i)\right] \; A_p\right]$$

For a finite plane of contamination, this reduction factor (RF) is reduced by multiplying it by a Table 6 (Reference 1) finite plane correction. This procedure assumes that the apertures extend from the basement floor to the ceiling.

In cases where the exposed portion of a basement wall gives the predominant contribution, the calculation corresponds to a detector location at about grade level. The use of Table 3 (Reference 1) also includes a contribution from direct radiation which should be excluded since the detector is below the contaminated planes and does not receive direct radiation.

2. Recommended Method

a. Procedure

All data necessary to make Engineering Manual calculations for

exposed basements are available from present Phase 1 data with the exception of the height of apertures in the exposed wall. The Engineering Manual method is therefore recommended for this calculation which can be accomplished by assuming that the apertures extend from the sill height determined in Phase 2 to the ceiling of the basement. This method will allow calculations to be based on a 3 foot detector height and will eliminate the excessive direct radiation now included in the calculation through the use of existing Table 3. Finite planes of contamination will be handled by differencing directional responses for scattered radiation and multiplying by a barrier reduction factor for limited planes (EM Chart 9).

TAB 1 compares partial basement exposure reduction factors calculated with Engineering Manual and Guide for Architects and Engineers procedures. Note that as stated on Page 31 of the description of the present Computer Program (see Reference 1), the PF for a basement with no exposure may be somewhat optimistic using the AE Guide.

b. Chart Changes

Tables 3, 4, and 6 of the present Computer Program (Reference 1) will no longer be needed in basement calculations. Table 1 will remain in the program since it is the same as used in the EM method. New tables representing Engineering Manual Chart 2 for wall barrier factor, Chart 5 for G_s and G_a directional responses, Chart 7 for scatter factor, Chart 8 for shape factor, and Chart 9 for wall-scatter barrier factor should be added to the program.

c. Functional Equations

The basic equation, using symbols contained in Table 5 of Reference 3, for each of the four sides is:

$$WAL1 = P_r B'_o (X'_o) \, B_w(X_i, 3') \left[(1-P_a) \quad (C_1+C_2) + P_a \; C_3 \right]$$

in which:

P_a = Fraction of wall <u>above</u> sill level occupied by apertures

$$C_1 = \Delta G_s(\omega)\ S_w(X_e)\ E(e)\ \Delta B_{ws}(\omega_s, X_e)$$

$$C_2 = \Delta G_a(\omega)\left[1 - S_w(X_e)\right] B_w(X_e, H_u)$$

$$C_3 = \Delta G_a(\omega)$$

(1) The equation is used four times for exposed basements for each plane of contamination on a building side. (Once on each contributing story for the region of the wall below the sill with $P_a = 0$ and once for the region above sill level.)

(2) If the plane of contamination is an infinite field, replace $\Delta B_{ws}(\omega_s, X_e)$ in C_1 by $B_w(X_e, H_u)$.

(3) Set $C_2 = C_3 = 0$ for the second, third, ... planes of contamination on a building side.

d. <u>Calculations</u>

(1) <u>Comments</u>

(a) If basement wall is not partially exposed, calculate the in and down contribution from the first story walls, then from the second story walls using the same computational scheme.

(b) If wall is partially exposed, calculate the contribution from the adjacent wall and first story wall only.

(c) The above two computations include no contribution from direct radiation. Thus, if the detector is above a plane of contamination, use the procedure for an upper story detector location.

(d) It is assumed in calculating (a) and (b) above, that the apertures have the correct lower sill level but extend all the way to the ceiling (the total area of apertures is not changed).

(e) Solid angle fractions (ω) are to be calculated using the equation

$$\omega(N,E) = \frac{2}{\pi} \tan^{-1} \left[\frac{E}{N\sqrt{E^2 + N^2 + 1}}\right]$$

Note: This equation is used to calculate solid angle fractions in all of the recommended procedures.

(2) Symbols Used

D = distance from detector to exterior wall

XE = exterior mass thickness of exposed basement wall

XEP = exterior mass thickness of first story wall above detector

XEQ = exterior mass thickness of second story wall above detector

XPR = mass thickness of first floor

XPS = mass thickness of second floor

XI = interior wall mass thickness between detector and contributing wall

AP = fraction of area of exposed exterior basement wall which is occupied by apertures

APP = fraction of area of exterior wall of first story above detector which is occupied by apertures

APQ = fraction of area of exterior wall of second story above detector which is occupied by apertures

P_r = ratio of the length of this wall to the perimeter of the building at detector height

L = length of this wall

HB = height of basement

HF = height of first story

HS = height of second story

HD = detector height above basement floor (3 ft)

HSB = height from basement floor to lower sill of apertures in exposed basement

HSF = height from first floor to lower sill of first story apertures

HSS = height from second floor to lower sill of second story apertures

HP = height of contaminated plane above first floor (negative values correspond to exposed basement)

D1 = distance from exterior wall to inner boundary of contaminated plane

D2 = distance from exterior wall to outer boundary of contaminated plane

(For the location of this data on the Phase 1 and 2 Data Collection Forms see TAB 2.)

(3) <u>Detail Calculations</u>

(Chart references are to the Engineering Manual.)

(a) Calculate the contribution from the adjacent wall penetrating below the aperture sill level. Set X_e = XE

<u>1</u>. Look up B_o' (X_o') - Chart 1, Case 3 Entry X_o' = XO = 0 (This will be unity for XO = 0.)

<u>2</u>. Look up B_w $(X_i, 3')$ Entry X_i = XI

<u>3</u>. $P_a = 0$

<u>4</u>. ZO = HB - HD + HP (from detector to ground)

<u>5</u>. W = 2D

<u>6</u>. Interchange W and L if L < W

7. $NO = 2 \times ZO/L$

8. $EO = W/L$

9. Calculate $\omega_u(NO,EO)$

Result: OMEG1

10. Repeat Steps 4 through 9 with new Z value

Z2 = HSB-HD (from detector to sill)

Result: OMEG2

11. Look up G_s(OMEG1), G_s(OMEG2), G_a(OMEG1), G_a(OMEG2) - from Chart 5

12. $\Delta G_s = G_s$ (OMEG2) - G_s(OMEG1)

13. $\Delta G_a = G_a$ (OMEG2) - G_a(OMEG1)

ΔG_s and ΔG_a should never be negative

14. Look up S_w(XE) - Chart 7

15. Look up E (EO) - Chart 8

16. HU = - HP/2 (height from plane of contamination to midwall)

Set HU=3' if above value is less than 3'

17. Look up B_w (X_e,HU) - Chart 2

18. If infinite plane, set $\Delta B_{ws} = B_w(X_e,HU)$

19. If finite plane adjacent to building, calculate

W1=2(D 2)

L1=L+W1

N1=2 x HU/L1

E1=W1/L1

Calculate ω(N1,E1)

OMEGS = ω(N1,E1)/2

Look up B_{ws} (OMEGS,X_e) - Chart 9

Set $\Delta B_{ws} = B_{ws}$

20. If finite plane detached from building, do 19 with D2 to get B_{ws2} and with D1 to get

B_{ws1}, then form

$\Delta B_{ws} = B_{ws2} - B_{ws1}$ (ΔB_{ws} should never be negative.)

[In general, only the first plane will contribute through the exposed wall. Outer planes may contribute through the first and second story walls. Only the region of the wall above the level of contamination will contribute wall scattered radiation. Consequently, OMEG1 in Step 12 (only) should be calculated with a ZO value from the detector to the plane if the plane lies between the floor level and ceiling for the wall whose contribution is under consideration (i.e., ZO = HB-HD+HP). P_a must be interpreted as the fraction of wall above the plane occupied by the apertures. Assuming that the apertures extend to the ceiling,

P_a = (aperture fraction from FOSDIC) x (wall height from floor to above floor)/ (wall height minus the distance that the plane is above the floor)

when the plane is below sill level, and

P_a = (aperture fraction from FOSDIC) x (wall height from floor to above floor)/ (wall height minus sill level)

when the plane lies between the sill level and the ceiling.

Neglect mutual shielding of skyshine. If the detached plane extends to infinity, set $B_{ws2} = B_w(\omega_e, HU)$.]

21. $C1 = (\Delta G_a)\ S_w E\ (\Delta B_{wa})$

22. $C2 = (\Delta G_a)(1-S_w)\ B_w$

23. $C3 = \Delta G_a$

24. $WAL1 = P_r B_o'(X_o)\ B_w(X_i, 3')\left[(1-P_a)\ (C1+C2) + P_a C3\right]$

Repeat Steps 1 - 24 for each plane and sum WAL1. If the plane is higher than the above floor, disregard it. Also, if a 2nd, 3rd, ...plane is lower than a closer-in plane, neglect the lower plane.

(b) Calculate the contribution from the adjacent wall penetrating above the sill level.

Repeat (a) with the following changes in the steps noted.

3. $P_a = (AP)(-HP)/\left[(HB)-(HSB)\right]$ (scaled up aperture fraction)

4. ZO=HSB-HD (from detector to sill - note this calculation will be available from (a))

10. Z2=HB-HD (from detector to first floor)

Obtain WAL2

(c) Calculate the contribution from the first story wall below the sill level.

Repeat (a) with (X_e = XEP) and

1. XO=XPR

3. P_a=0

4. ZO=HB-HD (from detector to first floor - these data were calculated in (b))

10. Z2=HSF+HB-HD (from detector to first story sill)

16. $HU = \frac{HF}{2} - HP$

Obtain WAL3

(d) Calculate the contribution from the first story wall above the sill level.

Repeat (a) with (X_e = XEP) and

1. XO=XPR

3. P_a=(APP) (HF)/(HF-HSF)

4. ZO=HSF+HB-HD [from detector to first story sill - available from (c)]

10. Z2=HF+HB-HD (from detector to second floor)

16. $HU = \frac{HF}{2} - HP$

Obtain WAL4

(e) WALDA=WAL1+WAL2+WAL3+WAL4

(f) Repeat (a-e) for the other three walls and sum the values for WALD to obtain the total contribution from all walls, planes, and stories. WALD = WALDA + WALDB + WALDC + WALDD

(g) When the contribution from the second story is required (see II.A.2.d.(1)(a) and (b) above)

1. Repeat (a) with (X_e=XEQ) and

   1. XO=XPR+XPS

   3. P_a=0

   4. ZO=HF+HB-HD [from detector to second floor - available from (d)]

   10. Z2=HSS+HF+HB-HD (from detector to second story sill)

   16. $HU = \frac{HS}{2} + HF - HP$

   Obtain WAL5 (contribution from below sill)

2. Repeat (a) with (X_e=XEQ) and

1. XO=XPR+XPS

3. P_a= (APQ)(HS)/(HS-HSS)

4. ZO=HSS+HF+HB-HD (available from above)

10. Z2=HS+HF+HB-HD (from detector to third floor)

16. HU= $\frac{HS}{2}$ +HF-HP

Obtain WAL6 (contribution from above sill)

3. The total contribution for this building side from the first and second stories is

WALDA=WAL3+WAL4+WAL5+WAL6

3. <u>Numerical Example</u>

Sample calculations using the recommended procedures are given for unexposed and exposed basements. Details of the building used in these examples are contained in TABS 3 and 4.

a. <u>Basement, Unexposed</u>

(1) <u>Contribution From A Side</u>

(a) <u>Data</u>

D = 70

XE = -

XEP = 60

XEQ = 60

XPR = 80

XPS = 60

XI = 20

AP = -

APP = 0.2

APQ = 0.2

$P_r = L_A/(L_A+L_B+L_C+L_D) = 80/2x(80+140) = 0.1817$

$L = L_A = 80$

HB = 13

HF = 10

HS = 10

HD = 3

HSB = -

HSF = 5

HSS = 5

HP = 0

D1 = -

D2 = -

It is determined that only an infinite plane contributes, and that the entire first and second story walls are struck by radiation from this plane, i.e., HP $\leq$ 0.

(b) Contribution from first story wall, below sill level

(Follow II. A. 2. d. (3) (c))

X_c = 60

1. XO = 80

   B'_o (80) = 0.0185

2. XI = 20

   B_w (20,3') = 0.60

3. P_a = 0

4. ZO = 13 - 3 = 10

5. W = 2 x 70 = 140

6. W = 80

   L = 140

7. NO = 2 x 10/140 = 0.143

8. EO = 80/140 = 0.57

9. OMEG1 = 0.82

10. Repeat 4 through 9 with new Z value.

    4. Z2 = 5 + 13 - 3 = 15

    5. W = 140

    6. W = 80

       L = 140

    7. NO = 2 x 15/140 = 0.214

    8. EO = 80/140 = 0.57

    9. OMEG2 = 0.73

11. G_s(OMEG1) = 0.195

G_s(OMEG2) = 0.268

G_a(OMEG1) = 0.0505

G_a(OMEG2) = 0.066

12. $\Delta G_s = 0.268 - 0.195 = 0.073$

13. $\Delta G_a = 0.066 - 0.0505 = 0.0155$

14. $S_w(60) = 0.63$

15. $E(0.57) = 1.37$

16. HU = (HF/2) - HP = 5

17. $B_w(60,5) = 0.22$

18. $\Delta B_{ws} = 0.22$

21. C1 = 0.073 x 0.63 x 1.37 x 0.22 = 0.0138

22. $C_2 = 0.0155 \times (1-0.63) \times 0.22 = 0.00126$

23. $C_3 = 0.0155$

24. $WAL3 = 0.1817 \times 0.0185 \times 0.60 \left[(1-0)\ (0.0138 + 0.00126) + 0 \times 0.0155\right] = 0.0000303$

Only one plane contributes.

(c) Contribution from first story wall above sill level

(Follow II. A. 2. d. (3) (d))

Only the changed values are noted.

3. $P_a = 0.2 \times 10 / (10-5) = 0.4$

4. to 9. OMEG1 = 0.73 (same as OMEG2 above)

10. 4. Z2 = 10 + 13 - 3 = 20

5. W = 140

6. W = 80

L = 140

7. NO = 2 x 20/140 = 0.286

8. EO = 0.57

9. OMEG2 = 0.66

11. G_s(OMEG1) = 0.268

G_s(OMEG2) = 0.301

G_a(OMEG1) = 0.066

G_a(OMEG2) = 0.0727

12. ΔG_s = 0.301 - 0.268 = 0.033

13. ΔG_a = 0.0727 - 0.0660 = 0.0067

21. C1 = 0.033 x 0.63 x 1.37 x 0.22 = 0.0063

22. C2 = 0.0067 (1-0.63) x 0.22 = 0.000545

23. C3 = 0.0067

24. WAL4 = 0.1817 x 0.0185 x 0.60 [(1-0.4) (0.0063 + 0.000545)
+ 0.4 x 0.0067] = 0.0000137

Only one plane contributes.

(d) Contribution from second story wall below sill level

(Follow II. A. 2. d. (3)(g) 1.)

Only the values which are different from the preceding calculation are noted.

1. XO = 80 + 60 = 140

B_o' (140) = 0.0015

3. P_a = 0

4. to 9. OMEG1 = 0.66 (same as OMEG2 in preceding calculation)

10. 4. Z2 = 5 + 10 + 13 - 3 = 25

7. NO = 2 x 25/140 = 0.357

9. OMEG2 = 0.60

11. G_s(OMEG1) = 0.301

G_s(OMEG2) = 0.335

G_a(OMEG1) = 0.0727

G_a(OMEG2) = 0.0785

12. ΔG_s = 0.335 - 0.301 = 0.034

13. ΔG_a = 0.0785 - 0.0727 = 0.0058

16. HU = 10/2 + 10 - 0 = 15

17. B_w(60,15') = 0.17

18. ΔB_{ws} = 0.17

21. C1 = 0.034 x 0.63 x 1.37 x 0.17 = 0.00499

22. C2 = 0.0058 x (1-0.63) x 0.17 = 0.000364

23. C3 = 0.0058

24. WAL5 = 0.1817 x 0.0016 x 0.60 $\Big[$(1-0) (0.00499 + 0.000364)

+ 0 x 0.0058$\Big]$ = 0.00000093

Only one plane contributes.

(e) Contribution from second story wall above sill level

(Follow II. A. 2. d. (3)(g) 2.)

Only the values which are different from the preceding calculation are noted.

3. P_a = 0.2 x 10/(10-5) = 0.4

4. to 9. OMEG1 = 0.6 (same as OMEG2 in preceding calculation)

10. 4. Z2 = 10 + 10 + 13 - 3 = 30

7. NO = 2 x 30/140 = 0.428

9. OMEG2 = 0.53

11. G_s(OMEG1) = 0.335

G_s(OMEG2) = 0.364

G_a(OMEG1) = 0.0785

G_a(OMEG2) = 0.0826

12. ΔG_s = 0.364 - 0.335 = 0.029

13. ΔG_a = 0.0826 - 0.0785 = 0.0041

21. C1 = 0.0029 x 0.63 x 1.37 x 0.17 = 0.00426

22. C2 = 0.0041 x (1-0.63) x 0.17 = 0.000258

23. C3 = 0.0041

24. WAL6 = 0.1817 x 0.0016 x 0.60 [(1-0.4) (0.00426 + 0.000258)

+ 0.4 x 0.0041] = 0.00000076

Only one plane contributes.

(f) Total Contribution from A side

WALDA = 0.000030 + 0.0000137 + 0.00000093 + 0.00000076

= 0.0000454

(2) Contribution from C side

Similarly, total contribution from side C is

WALDC = 0.0000454

(3) Contribution from B side

(a) Data for adjacent plane

Use the same data as for the A side with the following exceptions.

D = 40

$P_r = L_B/\sum L = 140/440 = 0.318$

L = 140

D2 = 20

It is determined that radiation from this plane strikes all of the first and second story walls.

(b) Contribution from first story wall below sill level (Adjacent plane)

Same results as in (1) (b) except for

5. W = 2 x 40 = 80

18. -

19. W1 = 2 x 20 = 40

$L1 = 140 + 40 = 180$

$N1 = 2 \times 5/180 = 0.0556$

$E1 = 40/180 = 0.222$

$\omega = 0.85$

$OMEGS = 0.425$

$B_{ws}(OMEGS, X_e) = 0.060$

$\Delta B_{ws} = 0.06$

21. $C1 = 0.073 \times 0.63 \times 1.37 \times 0.06 = 0.00375$

24. $WAL3 = 0.318 \times 0.0185 \times 0.60$

$$\left[(1-0)\ (0.00375 + 0.00126) + 0 \times 0.0155\right]$$

$= 0.0000177$

Only one plane contributes.

(c) Contribution from first story wall above sill level (Adjacent plane)

Same results as in (1)(c) except for

5. $W = 2 \times 40 = 80$

18. -

19. $\Delta B_{ws} = 0.06$ (same as in preceding calculation)

21. $C1 = 0.033 \times 0.63 \times 1.37 \times 0.06 = 0.00171$

24. $WAL4 = 0.318 \times 0.0185 \times 0.60$

$$\left[(1-0.4)\ (0.00171 + 0.00055) + 0.4 \times 0.0067\right]$$

$= 0.0000143$

Only one plane contributes.

(d) Contribution from second story wall below sill level (Adjacent plane)

Same results as in (1) (d) except for

5. $W = 2 \times 40 = 80$

18. -

19. $W1 = 2 \times 20 = 40$

$L1 = 140 + 40 = 180$

$N1 = 2 \times 15/180 = 0.1667$

$E1 = 40/180 = 0.222$

$\omega = 0.59$

OMEGS = 0.285

$B_{ws}(OMEGS, X_e) = 0.028$

$\Delta B_{ws} = 0.028$

21. $C1 = 0.029 \times 0.63 \times 1.37 \times 0.028 = 0.000701$

24. $WAL5 = 0.318 \times 0.0016 \times 0.60 \left[(1-0)\ (0.000701 + 0.000364) + 0 \times 0.0058\right] = 0.000000325$

The second plane contributes in this region since its elevation is between the second floor and the sill level. This contribution is calculated below in (3) (g)

(e) Contribution from second story wall above sill level (Adjacent plane)

Same results as in (1) (e) except for

5. $W = 2 \times 40 = 80$

18. =

19. $\Delta B_{ws} = 0.028$ (same as in preceding calculation)

21. $C1 = 0.029 \times 0.63 \times 1.37 \times 0.028 = 0.000701$

24. $WAL6 = 0.318 \times 0.0016 \times 0.60 \left[(1-0.4)\ (0.000701 + 0.000258) + 0.4 \times 0.0041\right] = 0.00000068$

The second plane also contributes. See (3)(g)

(f) Data for second plane

Use the same data as for the A side with the following exceptions.

$D = 40$

$P_r = 140/440 = 0.318$

$L = 140$

$HP = 12$

D1 = 20

D2 = 100

(g) Calculations for second plane

Since HF < HP < HF + HSS, the radiation does not strike all of the second story wall. Same results as in a. (1) (e) except for C2 = C3 = 0

3. P_a = APQ x HS/(HF + HS - HP)

= 0.2 x 10/(10 + 10 - 12) = 0.25

(Note, if HF + HSS < HP < HF + HS, the value for P_a in a. (1) (e) should be used.)

4. Z0 = HB - HD + HP = 13 - 3 + 12 = 22

5. W = 2 x 40 = 80

7. N0 = 2 x 22/140 = 0.314

9. OMEG1 = 0.63

11. G_s(OMEG1) = 0.32

12. ΔG_s = 0.364 - 0.318 = 0.046

16. HU = HS/2 + HF - HP = 10/2 + 10 - 12 = 3

17. B_w(60,3) = 0.25

18. -

20. W1 = 2 x 100 = 200

L1 = 140 + 200 = 340

N1 = 2 x 3/340 = 0.01765

E1 = 200/340 = 0.589

= 0.979

OMEGS = 0.49

B_{ws2}(OMEGS,X_c) = 0.15

Repeat with D1

W1 = 2 x 20 = 40

L1 = 140 + 40 = 180

$N1 = 2 \times 3/180 = 0.0333$

$E1 = 40/180 = 0.222$

$\omega = 0.905$

$OMEGS = 0.45$

$B_{ws1}(OMEGS, X_e) = 0.085$

$\Delta B_{ws} = 0.15 - 0.085 = 0.065$

21. $C1 = 0.046 \times 0.63 \times 1.37 \times 0.065 = 0.00258$

22. $C2 = 0$

23. $C3 = 0$

24. $WAL62 = 0.318 \times 0.0016 \times 0.60 \left[(1-0.25) \times 0.00258\right]$

$= 0.00000059$

(h) Total contribution from B side

$WALDB = 0.0000177 + 0.0000143 + 0.000000325 + 0.00000068$

$+ 0.00000059 = 0.0000336$

(4) Similarly the contribution from D is

$WALDD = 0.0000336$

(5) The total wall contribution is

$WALD = 0.0000454 + 0.0000336 + 0.0000454 + 0.0000336$

$= 0.000158$

b. Basement, Exposed

Same problem as before, except the infinite plane on the A side is located 5 feet below the first floor.

Since the basement is partially exposed, only the adjacent and first story contributions are calculated. Thus, we obtain the following contributions from the B, C, and D sides from the first story calculations for the unexposed basement.

$WALDB = 0.0000177 + 0.0000143 = 0.000032$

$WALDC = 0.0000300 + 0.0000137 = 0.0000437$

$WALDD = 0.000032$

(1) Contribution from A side

(a) Data

Same as a. (1) (a), unexposed, except

XE = 60

AP = 0.2

HSB = 10

HP = -5

(b) Contribution from exposed basement wall below sill level

(Follow II. A. 2. d. (3) (a))

$X_e = 60$

1. $X_o = 0$

   $B_o' = 1.0$

2. $X_i = 20$

   $B_w(X_i, 3) = 0.6$

3. $P_a = 0$

4. Z0 = 13 - 3 - 5 = 5

5. W = 2 x 70 = 140

6. W = 80

   L = 140

7. NO = 2 x 5/140 = 0.0714

8. EO = 80/140 = 0.57

9. OMEG1 = 0.91

10. 4. Z2 = 10 - 3 = 7

    7. NO = 2 x 7/140 = 0.1

    9. OMEG2 = 0.87

11. G_s(OMEG1) = 0.104

    G_s(OMEG2) = 0.145

    G_a(OMEG1) = 0.0280

    G_a(OMEG2) = 0.040

12. $\Delta G_s = 0.145 - 0.104 = 0.041$

13. $\Delta G_a = 0.040 - 0.028 = 0.012$

14. $S_w(60) = 0.63$

15. $E(0.57) = 1.37$

16. $HU = -(-5)/2 = 2.5$

$HU = 3$

17. $B_w(60,3) = 0.25$

18. $\Delta B_{ws} = 0.25$

21. $C1 = 0.041 \times 0.63 \times 1.37 \times 0.25 = 0.00884$

22. $C2 = 0.012 \times (1-0.63) \times 0.25 = 0.0011$

23. $C3 = 0.012$

24. $WAL1 = 0.1817 \times 1 \times 0.6 \times \left[(1-0)\ (0.00884 + 0.0011) + 0 \times 0.012\right] = 0.00108$

(c) Contribution from exposed basement wall above sill level

(Follow II. A. 2. d. (3) (b))

Same as preceding calculation except

3. $P_a = 0.2\ \left[-(-5)\right]/(13-10) = 0.333$

4. to 9. OMEG1 = 0.87 (same as OMEG2 in preceding calculation)

10. 4. $Z2 = 13 - 3 = 10$

9. OMEG2 = 0.82 (same as OMEG1 in a. (1) (b), unexposed.)

11. $G_s(OMEG1) = 0.145$

$G_s(OMEG2) = 0.195$

$G_a(OMEG1) = 0.040$

$G_a(OMEG2) = 0.0505$

12. $\Delta G_s = 0.195 - 0.145 = 0.050$

13. $\Delta G_a = 0.0105$

21. $C1 = 0.050 \times 0.63 \times 1.37 \times 0.25 = 0.0108$

22. $C2 = 0.0105 \times (1-0.63) \times 0.25 = 0.0097$

23. $C3 = 0.0105$

24. $WAL2 = 0.1817 \times 1 \times 0.6 \times \left[(1-0.333)\ (0.0108 + 0.0097) + 0.333 \times 0.0105\right] = 0.00187$

(d) Contribution from first story wall below sill level

Same as a. (1) (b), unexposed, with changed HP.

16. $HU = 10$

17. $B_w(60,10) = 0.18$

18. $\Delta B_{ws} = 0.18$

21. $C1 = 0.073 \times 0.63 \times 1.37 \times 0.18 = 0.0113$

22. $C2 = 0.0155 \times (1-0.63) \times 0.18 = 0.00103$

24. $WAL3 = 0.0000303 \times 0.18/0.21 = 0.000026$

(e) Contribution from first story wall above sill level

Same as a. (1) (c), unexposed, with preceding change associated with HP.

21. $C1 = 0.0063 \times 0.18/0.21 = 0.0054$

22. $C2 = 0.000545 \times 0.18/0.21 = 0.000468$

24. $WAL4 = 0.1817 \times 0.0185 \times 0.60 \left[(1-0.4)\ (0.0054 + 0.000468) + 0.4 \times 0.0067\right] = 0.0000125$

(f) Total contribution from A side

$WALDA = 0.00108 + 0.00187 + 0.000026 + 0.0000125 = 0.00299$

(2) Total Contribution for all walls

$WALD = WALDA + WALDB + WALDC + WALDD$

$WALD = 0.00299 + 0.000032 + 0.0000437 + 0.000032 = 0.0031$

B. Roof Contribution

1. Present Method

Roof contribution is presently calculated by the AE Guide method which uses the area of the roof and does not account for variations in contribution because of the shape. Inputs required to make this calculation are mass thicknesses of the partitions, floors and roof; width and length of the core and building; location of setbacks; and the perpendicular distance from the detector to the plane of the contributing roof.

2. Recommended Method

a. Procedure

The Engineering Manual (EM) method of calculating roof contribution requires no additional inputs of data. TABS 5 and 6 compare the contributions as calculated by the AE Guide and EM methods for roofs of various buildings which do not have interior partitions. TAB 7 compares contributions as calculated by the same two methods for roofs of buildings which have partitions. The EM method results in a small decrease in contribution for buildings without interior partitions, whereas larger differences are noted in rectangular buildings with partitions.

The Engineering Manual method is recommended for calculating main roof and setback roof contributions for all buildings without partitions and for those with partitions reported in Phase 1. Interior partition data from Phase 2 are not recommended for use in calculating roof contribution at this time. For buildings without uniform partitions from floor to floor there are too many required manipulations to justify machine computations. Survey experience indicates that many types of buildings such as apartments, hotels,

schools, hospitals, etc., have the same partition arrangement on most stories.

b. Chart Changes

Table 2 of Reference 1 will no longer be needed in roof calculations. New tables representing Engineering Manual Chart 4 for roof contribution and Shelter Design and Analysis Manual (see Reference 5). Chart 11 for vertical barrier factors should be added to the program. Table 7 will remain in the program for the skyshine correction to roof contribution.

c. Functional Equations

Using symbols contained in Table 5 of Reference 3, the basic equation for:

(1) a building with interior partitions but without a setback is

$$\text{RUFDOS} = \left[C_1 + (C_2 - C_1)\ B_i'\right] \left[\text{Skyshine Correction}\right]$$

in which:

$C_1 = C_o\ (\omega_u', X_o)$ Contribution from core

$C_2 = C_o\ (\omega_u, X_o)$ Contribution from total roof

B_i' = Interior partition barrier factor from Chart 11 of Reference 5

(2) a building with a setback (as illustrated by Figure 1 of Reference 1) is

$$\text{RUFDOS} = \left[C_1 + \tfrac{1}{2}(C_2 - C_1) + \tfrac{1}{2}(C_3 - C_4)\right] \left[\text{Skyshine Correction}\right]$$

in which additional contributions are

$C_3 = C_o(\omega_o', X_o)$ Contribution from total roof at height of setback

$C_4 = C_o(\omega_o, X_o)$ Contribution from core at height of setback.

d. Calculations

(1) Comments

(a) The center of the shelter area (data available in columns 44-49 of Phase 2 DCF) need not be the center of the building and more than one setback may be on the same story as illustrated by Fig. 4 of Reference 1, since the building is divided into four fictitious buildings. The roof calculation is repeated four times using Phase 2 detector location data and Phase 1 setback data. Total roof contribution is determined by adding one-fourth of each value.

(b) Because buildings of complicated shapes may be divided into several parts, a determination of whether the first contaminated plane is grade or a neighboring roof should be made as is done in the present program (see p. 25 of Reference 1). If the first contaminated plane is determined to be a roof, and the detector lies below it, the neighboring roof is treated as a peripheral setback with

X_o = the total mass thickness of horizontal barriers between the detector and the contributing roof in the part of the building containing the detector.

X_i = the sum of the mass thicknesses of the interior partitions and the exterior wall between the detector and the neighboring roof.

(c) Setbacks and neighboring roofs which lie below the detector level are treated as regular planes of contamination for ground contribution to detectors above grade.

(d) When Phase 2 data are not available for the location of the center of the shelter area, the detector is located in the center of the building part.

(e) Each quadrant is computed using an "average" interior partition weight which is proportional to the weight of the partitions along the sides of the shelter and the shelter dimensions.

(2) Symbols Used

A = Length of exterior wall on A side

B = Length of exterior wall on B side

CA = Shelter dimensions (parallel to side A)

CB = Shelter dimensions (parallel to side B)

DA = Distance to center of shelter from A wall

DB = Distance to center of shelter from B wall

H = Height of building (i.e., roof height)

HBS = Height at which setback begins

HD = Height of detector

HP = Height of contaminated planes

SA = Distance from face of setback to side A

SB = Distance from face of setback to side B

SC = Distance from face of setback to side C

SD = Distance from face of setback to side D

W_c = Width of the contaminated plane

X_o = Total overhead mass between detector and contamination

XIA, XIB, XIC, XID = Interior partition weight parallel to respective sides A, B, C, & D (Phase 1 Data only)

(3) Detailed Calculations

(a) Set up initial inputs (first quadrant)

1. Set RA = RB = RC = RD = 0

Set DC = B - DA, DD = A - DB

Find $XI1 = \frac{XIA \cdot CA + XIB \cdot CB}{CA + CB}$

$$XI2 = \frac{XIB \cdot CB + XIC \cdot CA}{CA + CB}$$

$$XI3 = \frac{XIC \cdot CA + XID \cdot CB}{CA + CB}$$

$$XI4 = \frac{XIA \cdot CA + XID \cdot CB}{CA + CB}$$

(b) Find location of setback (or roof) with respect to the detector and find the contribution, ignoring interior partitions (one quadrant).

1. If there is not a setback, set R9 = R10 = R11 = 0 and go to (k) 1.

2. Set Z = HBS(1) - HD. If $Z < 0$, set R9 = 0, do step (h) 1. and go to (i) 1.

3. If RA > DA or RB > DB, set R1 = R2 = 0 and go to (d) 1.

4. $L_1 = 2(DA-RA)$, $W_1 = 2(DB-RB)$, calculate ω_1 (if W > L, interchange W & L).

5. If RC > DC, D1 = RC - DC; if not, D1 = 0, $\omega_2 = 0$, $\omega_4 = 0$, go to (b) 7.

6. $L_2 = 2D1$, $W_2 = 2(DB-RB)$, calculate ω_2

7. If RD > DD, D2 = RD - DD; if not, D2 = 0, $\omega_3 = 0$, $\omega_4 = 0$, go to (b) 10.

8. $L_3 = 2(DA-RA)$, $W_3 = 2D2$, calculate ω_3.

9. $L_4 = 2D1$, $W_4 = 2D2$, calculate ω_4.

10. $R1 = C_o(\omega_1, X_o) - C_o(\omega_2, X_o) - C_o(\omega_3, X_o) + C_o(\omega_4, X_o)$, Chart 4 of EM.

(c) Find location of setback (or roof) with respect to the interior partitions and find the contribution <u>inside</u> the core area from this setback (or roof).

<u>1.</u> If DA - RA $<\frac{1}{2}$ CB, set CB = 2 (DA-RA)

<u>2.</u> If DB - RB $<\frac{1}{2}$ CA, set CA = 2 (DB-RB)

<u>3.</u> If D1 $>\frac{1}{2}$ CB, set R2=0 and go to (d) <u>1.</u>

<u>4.</u> If D2 $>\frac{1}{2}$ CA, set R2=0 and go to (d) <u>1.</u>

<u>5.</u> L_5 = CB, W_5 = CA, calculate ω_5

<u>6.</u> L_6 = 2D1, W_6 = CA, calculate ω_6

<u>7.</u> L_7 = CB, W_7 = 2D2, calculate ω_7

<u>8.</u> $R2 = C_o(\omega_5) - C_o(\omega_6) - C_o(\omega_7) + C_o(\omega_4)$

(d) Find the total dose from this setback or roof area (R3).

<u>1.</u> Find $(R1-R2)\cdot B_i'(XI1) + R2$, $B_i'(XI)$ is Chart 11 of Reference 5.

<u>2.</u> R3= (d) <u>1.</u>

(e) Find the total dose for the second quadrant.

<u>1.</u> Repeat (b) <u>3.</u> through (d) <u>1.</u> for quadrant 2 (see cyclic permutation table in section (n))

<u>2.</u> $R4 = (R1-R2)\cdot B_i'(XI2) + R2$

(f) Find the total dose for the third quadrant.

<u>1.</u> Repeat (b) <u>3.</u> through (d) <u>1.</u> for quadrant 3 (see cyclic permutation table in section (n))

<u>2.</u> $R5 = (R1\cdot R2)\cdot B_i'(XI3) + R2$

(g) Find the total dose for the fourth quadrant and sum the four quadrants.

<u>1.</u> Repeat (b) <u>3.</u> through (d) <u>1.</u> for quadrant 4 (see cyclic permutation table in section (n))

<u>2.</u> Cycle back to 1st quadrant (see permutation table in section (n))

<u>3.</u> $R6 = (R1-R2)\cdot B_i'(XI4) + R2$

4. R7 = R3 + R4 + R5 + R6

(h) Find the total dose at the setback level for a roof using the dimensions of the building above the setback (as opposed to the initial building dimensions).

1. Set RA = SA(1), RB = SB(1), RC = SC(1), RD = SD(1)

2. Repeat (b) 3. through (g) 3.

3. R8 = R3+R4+R5+R6

4. R9 = (R7-R8) x skyshine factor (X_o)

(i) Compute the second setback contribution.

1. If there is NOT a second setback, set R10=R11=0 and go to (k) 1.

2. If [Z = HBS(2)-HD] < 0, set R10=0, do (i) 5. and go to (j) 1.

3. Set X_o for the 2nd setback level. Set Z=HBS(2)-HD

4. Repeat (b) 3. through (g) 4.

5. Set RA=SA(2), RB=SB(2), RC=SC(2), RD=SD(2)

6. Repeat (b) 3. through (g) 3.

7. R8 = R3+R4+R5+R6

8. R10 = (R7-R8) x Skyshine factor (X_o)

(j) Compute the third setback contribution.

1. If there is NOT a third setback, set R11=0 and go to (k) 1.

2. If [Z=HBS(3)-HD] < 0, set R11=0, do (j) 5. and go to (k) 1.

3. Set X_o for the 3rd setback level.
Set Z=HBS(3)-HD

4. Repeat (b) 3. through (g) 4.

5. Set RA=SA(3), RB=SB(3), RC=SC(3), RD=SD(3)

6. Repeat (b) 3. through (g) 3.

7. R8=R3+R4+R5+R6

8. R11=(R7-R8) x Skyshine Factor (X_o)

(k) Compute the true roof contribution.

1. Set Z=H-HD, Set X_o for mass between detector and roof.

2. Repeat (b) 3. through (g) 4.

3. R12=R7 x Skyshine Factor (X_o)

(ℓ) Compute the dose from the adjacent roofs.

(Use test for neighboring roof on Page 25 of Reference 1)

1. Set R13=R14=R15=R16=0

2. If there is an adjacent roof on the A side

(a) Repeat (a) 1.

(b) Set XI1=XI1+XE(A side) and XI4=XI4+XE(A side)

(c) Set Z=HP-HD and if Z $\leq$ 0, set R13=0 and go to (ℓ) 3.

(d) Repeat (b)3. through (d)2. and (g)1. through (g)3.

(e) R17=R3+R6

(f) Set RA=-W_c(1st,A)=width of first contaminated plane on A Side

(g) Repeat (ℓ) 2. (d)

(h) Set R13=R3+R6-R17

3. If there is an adjacent roof on the B side

(a) Repeat (a) 1.

(b) Set XI1=XI1+XE(B side) and XI2=XI2+XE(B side)

(c) Set Z=HP-HD and if Z $\leq$ 0, set R14=0 and go to (ℓ)4.

(d) Repeat (b) 3. through (e) 2.

(e) R17=R3+R4

(f) Set RB=-W_c(1st,B)=width of first contaminated plane on B side

(g) Repeat (ℓ) 3. (d)

(h) R14=R4+R3-R17

4\. If there is an adjacent roof on the C side

(a) Repeat (a) 1.

(b) Set XI2=XI1+XE(C side) and XI3=XI3+XE(C side)

(c) Set Z=HP-HD and if $Z \leq 0$, set R15=0 and go to (ℓ)5.

(d) Repeat (e) 1., (e) 2., (f) 1. and (f) 2.

(e) R17=R4+R5

(f) Set RC=-W_c(1st,C) = width of first contaminated plane on C side

(g) Repeat (ℓ) 4. (d)

(h) R15=R4+R5-R17

5\. If there is an adjacent roof on the D side

(a) Repeat (a) 1.

(b) Set XI3=XI3+XE(D side) and XI4=XI4+XE(D side)

(c) Set Z=HP-HD and if $Z \leq 0$, set R16=0 and go to (m)1.

(d) Repeat (f)1., (f)2., (g)1., (g)2. and (g)3.

(e) R17=R5+R6

(f) Set RD=-W_c(1st,D) = width of first contaminated plane on D side

(g) Repeat (ℓ) 5. (d)

(h) R16=R5+R6-R17

(m) Total Roof Contribution.

Add up the total contributions from the setbacks, true roof, and adjacent roofs.

1\. RUFDOS=$\frac{1}{4}$ [R9+R10+R11+R12+R13+R14+R15+R16]

(n) Cyclic Permutation Table

Quadrant	(1)	(2)	(3)	(4)	(1)
	DA →	DC →		DA →	→
Function	DB →		DD →		DB
	DC →	DA →		DC →	→
	DD →		DB →		DD
	RA →	RC →		RA →	→
	RB →		RD →		RB
	RC →	RA →		RC →	→
	RD →		RB →		RD

3. <u>Numerical Example</u>

The following sample calculation is for roof contribution from a building with 2 setbacks on the same story. For the detailed description of this building see TABS 3 and 4.

(a) Set up initial inputs.

<u>1.</u> RA=RB=RC=RD=0 $\quad X_o=60$

XI1=XI2=XI3=XI4=0

(b) Locate and calculate without partitions.

<u>2.</u> Z=30-23=7'

<u>4.</u> $L_1=2(70)=140$, $W_1=2(40)=80$, $\omega_1=\underline{.873}$

<u>5.</u> $\omega_2=\omega_4=0=\omega_3$

<u>10.</u> $R1=C_o(\omega_1, X_o)=C_o(.873, 60)=\underline{0.058}$

(c) Locate and calculate inside partitions.

<u>5.</u> $L_5=70, W_5=40$

<u>6.</u> $\omega_6=\omega_7=\omega_4=0$

<u>8.</u> $R2=C_o(\omega_5) = C_o(.75, 60) = \underline{0.058}$

(d) Find total contribution.

<u>1.</u> $R3=(R1-R2)\ B_1'\ (20) + R2 = 0 + 0.058$

<u>2.</u> R3=0.058

(e), (f) and (g) Find contributions and from symmetry,

R4=R5=R6=R3=0.058

<u>4.</u> R7=0.232

(h) Find total contributions from the dimensions of the building above setback.

<u>1.</u> RA=0, RB=0, RC=80, RD=10

<u>2.</u> $L_1=140$, $W_1=80$, $\omega_1=0.873$

D1=10, D2=0

$L_2=20$, $W_2=40$, $\omega_2=.60$

$\omega_3=\omega_4=0$

$R1=C_o(.873,60) - C_o(.60,60) = 0.058 - 0.051 = 0.007$

$L_5= 70$, $W_5=40$, $\omega_5=.75$

$L_6=20$, $W_6=40$, $\omega_6=.57$

$\omega_7=0$

$R2=C_o(.75,60) - C_o(.51,60) = 0.058 - 0.051 = 0.007$

$R3 = 0.007$

$R4 = R5 = 0$ because $SC > 70'$

Given DA=70, DB=40, DC=70, DD=40, RA=0 ,

RB=10, RC=80, RD=0

$L_1=140$, $W_1=60$, $\omega_1=.842$

<u>D1=10</u> , <u>D2=0</u>

$L_2=20$, $W_2=60$, $\omega_2=.62$

$D2=0$, $\omega_3=\omega_4=0$

$R1=C_o(.842,60) - C_o(.62,60) = .058 - .051 = 0.007$

$L_5=70$, $W_5=40$, $\omega_5=.75$

$L_6=20$, $W_6=40$, $\omega_6=.57$

$\omega_7=0$

$R2=C_o(.75,60)- C_o(.57,60) = 0.007$

$R6= 0.007$

<u>3.</u> $R8=0.007+0+0+0.007=0.014$

<u>4.</u> $R9= (0.232-0.014)\ 1.07 = (0.218)\ 1.07 = \underline{0.234}$

(i) Compute second setback.

<u>1.</u> No more setbacks; therefore, R10=R11=0

(k) Compute roof contribution.

<u>1.</u> $\underline{Z} = 50-23=\underline{27}$ $X_o=180$

2. $L_1=140$, $W_1=60$, $\omega_1=.48$ $\quad C_o(.48,180)=0.0029$

$L_2=20$, $W_2=60$, $\omega_2=.17$ $\quad C_o(.17,180)=0.0016$

$\omega_3=\omega_4=0$

$R1=0.0029 - 0.0016 = 0.0013$

$L_5=70$, $W_5=40$ $\quad \omega_5=.33$

$L_6=20$, $W_6=40$ $\quad \omega_6=.14$

$\omega_7=0$

$R2=C_o(.33,180) - C_o(.14,180) = 0.0024 - 0.0016 = 0.0008$

$R3=(0.0013 - 0.0008)\ (.48) + 0.0008 = 0.00104$

R4 uses the values:

$L_1=140$, $W_1=80$, $\omega=.59$, $C_o=0.0030$ and

$R1=0.0030 - 0.0016 = 0.0014$

$R4=(0.0014 - 0.0008)\ (.48) + 0.0008 = 0.00109$

$R5=R6=0$

$R7=0.00104 + 0.00109 + 0 + 0 = 0.00213$

3. $R12 = (0.00213)\ 1.00 = 0.00213$

(l) Compute dose from adjacent roof.

1. $R13=R14=R15=R16=0$

(m) Find the total roof contribution.

1. $RUFDOS=\frac{1}{4}\left[0.234 + 0 + 0 + 0.00213 + 0 + 0 + 0 + 0\right]$

$=\frac{1}{4}\left[0.23613\right] = \underline{0.0590}$

C. Ground Contribution - Stories Above Grade

1. Present Method

The present method of computing ground contribution for stories above grade is essentially the AE Guide method except that no correction is made for aperture sill height. Apertures are treated by multiplying a Table 3 (Reference 1) value at $X_e=0$ by the percentage of apertures (therefore, apertures are considered to extend from floor to ceiling). Table 3 includes a contribution from direct radiation which should be considerably reduced when it penetrates the solid wall below the sill level of an aperture. Contribution from finite planes of contamination is reduced by multiplying it by a Table 6 (Reference 1) value.

Inputs required in the present procedure are mass thicknesses of the partitions, exterior walls, and floors; width and length of the building; height of building, first story and upper stories; and the fraction of apertures on each floor.

2. Recommended Method

a. Procedure

(1) Major sources of difficulty in developing procedures for calculation of contribution to stories above grade are as follows:

(a) For detectors below sill level one must treat separately the directional responses below and above the detector.

(b) Buildings of interest to the OCD shelter program usually are found in metropolitan areas and typically would be surrounded by limited planes of contamination. For many, if not most of the potentially valuable above-grade shelter areas, the mutual shielding situation is such that very little, if

any direct radiation is received through the adjacent wall. Much more direct radiation is expected from the story below, but frequently direct radiation will be absent there also. On the other hand, there will almost always be some wall scattered radiation. Again, separation of the direct from the scattered components is indicated to be desirable.

(c) Because of the importance of direct radiation in many cases and the apparent need to separate it from the scattered and skyshine components, it appears important to correct this for height as is done in EM Chart 6.

(2) In order to properly correct for the difficulties outlined above, it is recommended that the Engineering Manual method be used in computing ground contribution to above-ground areas. Present input data plus the aperture sill height data from Phase 2 are adequate for this procedure if the apertures are assumed to extend from sill level to the ceiling. In addition to improving the aperture contribution calculation, the EM method will allow for more adequate handling of variable story heights and will take into account rectangular building shapes. Finite planes of contamination will be handled in the usual EM method by differencing directional responses. TAB 8 indicates the decrease in reduction factor by using the EM method.

(3) A "chart procedure" using EM data but using principles of the AE Guide was considered. This procedure yields results more accurate than the present computer program but considerably less accurate than the EM results. Approximately the same amount of data and charts are required; therefore, the EM method was felt to be most desirable.

b. Chart Changes

For the calculation of ground contribution to areas above grade, Table 1 will remain in the program and Tables 3, 5, 6, and 8 are not needed. The EXTRAP procedure which accounts for contribution from sources beyond the reported contaminated planes is also not needed. This will be treated by considering that the third reported plane extends to infinity when the detector is above all reported planes of contamination. New tables are required to represent data in Engineering Manual Chart 1, Case 1, for the barrier factor of the floor below the detector; Chart 5 for G_s and G_a directional responses; Chart 6 for G_d directional response; Chart 7 for scatter factor; Chart 8 for shape factor; and Chart 9 for wall-scatter barrier factor.

c. Functional Equations

The basic equations, using symbols contained in Table 5 of Reference 3, for each of the four sides are:

Case 1. Detector is below aperture sill level in adjacent wall

$$\begin{aligned} C'_g = P \Big[& B'_o(X'_o) \left[A_u C'_6 + (1-A_u) \quad (C_6 + \sum C_1)\right] \\ & + A_a C'_7 + (1-A_a) C_7 + \sum \big[(1-A_a) C'_2 \\ & + C''_2 + C_3\big] + B_o(X_f) \sum \left[A_1 C'_5 + (1-A_1) \quad (C_5 + C_4)\right] \Big] \end{aligned}$$

Case 2. Detector is above aperture sill level in adjacent wall

$$\begin{aligned} C'_g = P \Big[& B'_o(X'_o) \quad \left[A_u C'_6 + (1-A_u) (C_6 + \sum C_1)\right] \\ & + A_p (\sum C'_3 + C'_6) + (1-A_p) \left[\sum (C'_2 + C''_2 + C_3) + C_6\right] \\ & + B_o (X_f) \sum \left[A_1 C'_5 + (1-A_1) \quad (C_5 + C_4)\right] \Big] \end{aligned}$$

where the summations are taken over the contributing contaminated planes, and

C_1 = wall scatter from story above =

$$\left[B_{ws}(X_e,\omega_s)-B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_u'')-G_s(\omega_u)\right] S_w(X_e)\ E\ (J)$$
$$B_w(X_i,3').$$

C_2' = wall scatter from detector story =

$$\left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_u) - G_s(\omega_u')\right] S_w(X_e)\ E(J)\quad B_w(X_i,3').$$

C_2'' = wall scatter from detector story below detector level =

$$\left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right] G_s(\omega_l)\ S_w(X_e)\ E\ (J)\ B_w(X_i,3').$$

C_3 = direct through detector story wall =

$$B_w(X_e,H)\ \left[G_d(\omega_l,H) - G_d(\omega_l',H)\right]\left[1-S_w(X_e)\right]\ B_w(X_i,3').$$

C_3' = direct through apertures in detector story wall =

$$B_w(0,H)\ \left[G_d(\omega_l,H) - G_d\ (\omega_l',H)\right]\ B_w(X_i,3').$$

C_4 = wall scatter from story below =

$$\left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_l'') - G_s(\omega_l)\right] S_w(X_e)\ E\ (J)$$
$$B_w(X_i,3').$$

C_5 = direct through wall of story below =

$$B_w(X_e,H'')\ B_w(X_i,3')\left[G_d(\omega_l'',H) - G_d(\omega_l,H)\right]\left[1-S_w(X_e)\right].$$

C_5' = direct through apertures in wall of story below =

$$B_w(0,H'')\ B_w(X_i,3')\left[G_d(\omega_\ell'',H) - G_d(\omega_l,H)\right].$$

C_6 = skyshine through wall of story above =

$$B_w(X_e,H'')\left[G_a(\omega_u'') - G_a(\omega_u)\right]\left[1-S_w(X_e)\right] B_w(X_i,3).$$

C_6' = skyshine through apertures in story above =

$$B_w(0,H'')\left[G_a(\omega_u'') - G_a(\omega_u)\right]\ B_w(X_i,3').$$

C_7 = skyshine through wall of detector story =

$$B_w(X_e,H')\ \left[G_a(\omega_u) - G_a(\omega_u')\right]\left[1-S_w(X_e)\right] B_w(X_i,3').$$

C_7' = skyshine through apertures in wall of detector story =

$$B_w(0,H')\ \left[G_a(\omega_u) - G_a(\omega_u')\right]\ B_w(X_i,3').$$

A_u = area fraction of apertures in wall of story above.

A_p = area fraction of apertures in adjacent story wall.

$A_a = \frac{h_a A_p}{h_a - 3}$ = area fraction of apertures above detector on adjacent story.

A_l = area fraction of apertures in wall of story below.

d. Calculations

(1) Comments

(a) Areaways reported in Phase 2 are ignored for contribution to above ground areas. Planes of contamination are used as reported in Phase 1.

(b) Mutual shielding of skyshine is taken into account on both the adjacent story and the story above. The value of H used in the height corrected wall barrier factor is a weighted average height of those planes which preceed the first shielding plane (if any). The average is weighted by plane width.

(c) When the detector is above all planes of contamination on a side, the third plane is considered to extend to infinity to account for contribution from sources beyond the last reported plane.

(d) A direct radiation component for each plane is calculated for only that portion of the plane actually seen at the detector position through the relevant wall. This applies to both the adjacent story and the story below. The height corrected directional response functions are used.

(e) Wall scattered radiation components are calculated from each of the three stories; detector, above and below. When

a contaminated plane is detached from the exterior wall, the calculation is done as indicated in Figure P-1a.

When a contaminated plane is partially shielded from the exterior wall by a preceding plane, the calculation is done as indicated in Figure P-1b.

When a contaminated plane is partially shielded from the exterior wall so that the midpoint of the wall does not see the plane, the calculation is done as indicated in Figure P-1c.

Whereas these illustrations are for the detector story only, analagous procedures are used for the other stories.

(f) When there is a contribution from the last plane on the FOSDIC form, $B_{ws}(X_e,\omega_s)$ is replaced with $B_w(X_e,H)$ (see the equations in Figure P-1).

(g) If the detector is below sill height, the aperture is assumed to extend from the detector height (3') to the ceiling.

(h) If the detector is above sill height, the aperture is assumed to extend from floor to ceiling.

(i) The percentage of apertures is used for apertures in the walls of the stories above and below.

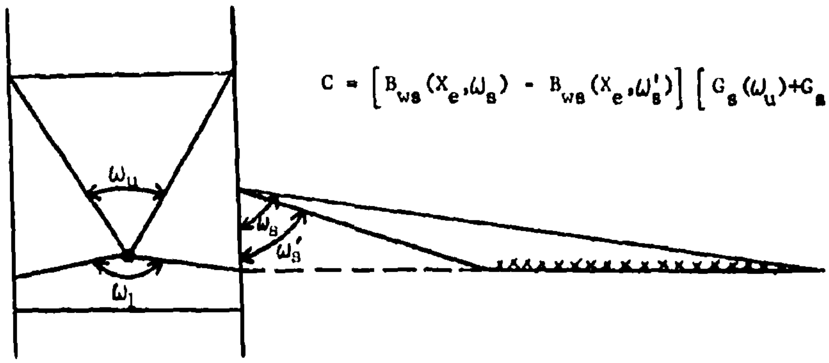
(j) Detector location is in the center of each story since Phase 2 data are not available for all stories.

(k) The effective mass thicknesses, X_e and X_i, are understood to be those of the walls on the story (above, detector, or below) for which a particular calculation is being done.

FIGURE P-1

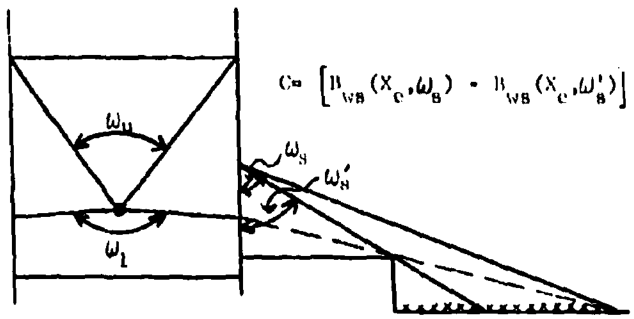
Contaminated Plane Shielding Calculations

a.



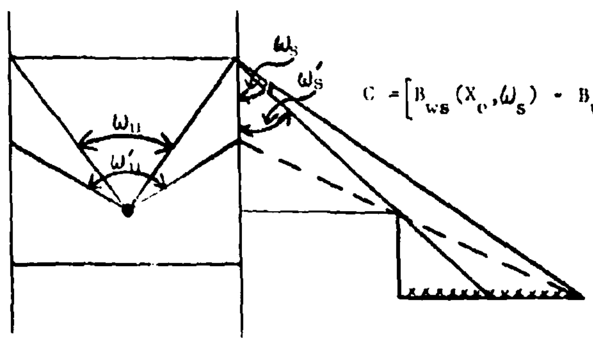
$$C = \left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_u)+G_s(\omega_l)\right]S_w(X_e)E(\varepsilon).$$

b.



$$C = \left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_u) + G_s(\omega_l)\right] S_w(X_e)E(\varepsilon).$$

c.



$$C = \left[B_{ws}(X_e,\omega_s) - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_u) - G_s(\omega_u')\right] S_w(X_e)E(\varepsilon$$

(2) <u>Symbols Used</u>

A = area fraction of apertures in a story wall

d = horizontal distance from the detector to the exterior wall at the detector story level, i.e., $d = \frac{1}{2} L_t$

D_1 = horizontal distance from the exterior wall at the detector story level to the inner edge of a contaminated plane. For the i^{th} plane, including k setback roofs below the detector,

$$D_1 = \alpha_k + \sum_{j=1}^{i-1} \left[\text{ plane width from FOSDIC 20} \right]_j ,$$

where $\alpha_k = \mathcal{X}$ for the k^{th} setback as ordered on the FOSDIC form

D_2 = horizontal distance from the exterior wall at the detector story level to the outer edge of a contaminated plane. For the i^{th} plane, including k setback roofs below the detector story

$$D_2 = \alpha_k + \sum_{j=1}^{i} \left[\text{ plane width from FOSDIC 20} \right]_j ,$$

where $\alpha_k = \alpha$ for the k^{th} setback as ordered on the FOSDIC form

h_a = height of detector story

h_u = height of story above

h_l = height of story below

H = height of detector above a contaminated plane

$H = 3 + \sum \left[\text{story heights from FOSDIC 18}\right] - \left[\text{contaminated plane height from FOSDIC 20}\right]$

H_s = height of a setback above the first contaminated plane

$H_s = \left[\text{FOSDIC 19e, 19j, or 19o}\right] - \left[\text{FOSDIC 20a, 20b, 20c, or 20d}\right]$

J = ϵ if $\epsilon \leq 1$. Otherwise $J = 1/\epsilon$

L_p = building length parallel to the exterior wall at the detector story level

L_t = building length perpendicular to the exterior wall at the detector story level

P = perimeter ratio (length of wall/total perimeter of building)

X_e = effective mass thickness of the exterior wall

X_f = effective mass thickness of the floor

X_i = effective mass thickness of interior partition

X_o = effective mass thickness of the ceiling

α = horizontal distance from the plane of the exterior wall at grade level to the building face above a setback

ϵ = L_p/L_t

ω = solid angle fraction. If Ω is the solid angle in units of steradians, then $\omega = \Omega/2\pi$

$$\omega = \omega(\mu, \nu) = \frac{2}{\pi} \tan^{-1}\left(\frac{\mu}{\nu\sqrt{\mu^2+\nu^2+1}}\right)$$

(For the location of this data on the Phase 1 and 2 Data Collection Forms, see TAB 2.)

(3) Detailed Calculations

(a) Establishment of Contaminated Planes and Adjustment of Building Dimensions When There Are Setbacks Below the Detector

For a specific detector location, the following calculations are to be done for all four walls before the ground contribution calculations are begun.

A. Determine if there are any setbacks on this side. One of the following situations will apply.

1. There are none and all sides have not been tested. Set IRF = 0 and proceed to test the next side.

2. There are none and all sides have been tested. Set IRF = 0 and proceed to the ground contribution calculations for the first side.

3. At least one setback is found on this side. Proceed to step B below.

B. Let $(H_s)_i$ be the height above the first contaminated plane (Item 20, FOSDIC form) of the i^{th} setback on this side. Let H be the detector height above the first contaminated plane on this side.

1. For each $(H_s)_i$ determine if

$$(H_s)_i < H \qquad a)$$

2. If a) is true for at least one setback, proceed to step C.

3. If a) is false for all setbacks, proceed to step E.

C. Perform steps 1 and 2 below:

1. Order the setbacks for which a) is true in order of decreasing magnitude of H_s. The setback with largest H_s becomes the first contaminated plane. The setback with second largest H_s becomes the second contaminated plane, etc. The contaminated planes

given in Item 20 of the FOSDIC form are given successive numbers following those assigned to the setbacks.

The total possible number of contaminated planes is six.

2. The D_1 and D_2 values for the setback contaminated planes are determined from the information in Item 19, FOSDIC form.

3. Proceed to step D.

D. Let α be the distance from the plane of the exterior wall at grade to the face of the building above the highest ordered setback from the set of setbacks ordered in step C. 1. above. Let L_t' be the dimension of the building perpendicular to this side at grade level. Let L_t be the dimension of the building perpendicular to this side at this story level which has been corrected for setbacks. Perform the following steps:

1. $L_t = L_t' - \alpha$

2. Replace L_t' with L_t for use in subsequent calculations at this story level.

3. Proceed to step E.

E. If a) was found to be false in step B for any setback, proceed to do sequentially steps 1, 2, and 3 below Otherwise, set IRF=0 and proceed to step F.

1. Determine if

$$(H_s)_i \leq H + h_a - 3 \qquad \text{b)}$$

for each setback for which a) is false.

2. If b) is true for any setback, do not calculate the ground contribution from the story above for this side, i.e., set IRF=1.

Otherwise set IRF=0.

3. Proceed to step F.

F. If all four sides have been considered, proceed to step G. If not, proceed to consideration of the next side and transfer back to step

A above.

G. Determine d for each side from the equation:

$$d = \frac{1}{2} L_t$$

Proceed to ground contribution calculations.

(b) Ground Contribution Calculations.

Steps A through J are repeated for each side of the building for each detector position.

A. Define:

$$\text{Tan } R_1 = d/3$$

$$\text{Tan } R_2 = d/(h_1+3)$$

Proceed to next step.

Steps B through G are repeated for each contaminated plane or until the loop is broken by a transfer to step H.

B. Define:

$$\text{Tan } S_1 = (D_1+d)/H$$

$$\text{Tan } S_2 = (D_2+d)/H$$

$$\text{Tan } T_1 = D_1(H + \tfrac{1}{2} h_a - 3)$$

$$\text{Tan } T_2 = D_2/(H + \tfrac{1}{2} h_a - 3)$$

$$\text{Tan } U_1 = D_1/(H - \tfrac{1}{2} h_1 - 3)$$

$$\text{Tan } U_2 = D_2/(H - \tfrac{1}{2} h_1 - 3)$$

$$\text{Tan } V_1 = D_1/(H + h_a + \tfrac{1}{2} h_u - 3)$$

$$\text{Tan } V_2 = D_2/(H + h_a + \tfrac{1}{2} h_u - 3)$$

$$\text{Tan } W_1 = D_1/(H + h_a - 3)$$

$$\text{Tan } W_2 = D_2/(H + h_a - 3)$$

$$\text{Tan } X_1 = D_1/(H-3)$$

$\text{Tan } X_2 = D_2/(H-3)$

$\text{Tan } Y_1 = D_1/(H + h_a + h_u - 3)$

$\text{Tan } Y_2 = D_2/(H + h_a + h_u - 3)$

Proceed to next step.

C. Determine wall-scattered component from story above, C_1.

1. If this is the top story or IRF=1, set $C_1=0$ and transfer to step D. Otherwise proceed to the next step.

2. If $H+h_a+h_u-3 \leq 0$ set $C_1=C_2'=C_2''=C_3=C_3'=C_4=C_5=C_5'=0$ and transfer to step H. Otherwise proceed to the next step.

3. If $H+h_a-3 \leq 0$ set $C_2'=C_2''=C_3=C_3'=C_4=C_5=C_5'=0$ and proceed to the next step. Otherwise transfer to step 8 below.

4. If $H+h_a+\frac{1}{2}h_u-3 \leq 0$ proceed to next step. Otherwise transfer to step 6 below.

5. Calculate:

$$\omega_s' = \tfrac{1}{2}\omega\left[(L_p+2D_1)/2D_1, (\text{Tan} Y_1)^{-1}\right]$$

or $\omega_s'=0$ if $\text{Tan } Y_1=0$.

$$\omega_s = \tfrac{1}{2}\omega\left[(L_p+2D_2)/2D_2, (\text{Tan } Y_2)^{-1}\right]$$

or $\omega_s=\frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form. Transfer to step 7 below.

6. Calculate:

$$\omega_s' = \tfrac{1}{2}\omega\left[(L_p+2D_1)/2D_1, (\text{Tan } Y_1)^{-1}\right]$$

or $\omega_s' = 0$ if Tan $V_1 = 0$.

$$\omega_s = \tfrac{1}{2}\omega\left[(L_p + 2D_2)/2D_2, (\text{Tan } V_2)^{-1}\right]$$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

Proceed to next step.

7. Define:

$$\omega_u = \omega(\epsilon, -H/d)$$

$$\omega_u'' = \omega\left[\epsilon, (h_a + h_u - 3)/d\right]$$

$$C_1 = \left[B_{ws}(X_e, \omega_s) - B_{ws}(X_c, \omega_s')\right]\left[G_s(\omega_u'') - G_s(\omega_u)\right] S_w(X_e) E(J) B_w(X_1, 3),$$

or

$$C_1 = \left[B_w(X_e, H'') - B_{ws}(X_c, \omega_s')\right]\left[G_s(\omega_u'') - G_s(\omega_u)\right] S_w(X_e) E(J) B_w(X_1, 3),$$

if $\omega_s = \frac{1}{2}$. Where $H'' = H + h_a + \frac{1}{2} h_u - 3$ or $H'' = 3$ whichever is algebraically larger.

Transfer to step H.

8. If Tan V_2 for any preceding plane is greater than or equal to Tan V_2 for this plane, proceed to the next step. Otherwise transfer to step 11 below.

9. If Tan Y_2 for any preceding plane is greater than or equal to Tan Y_2 for this plane, set $C_1 = 0$ and transfer to step D. Otherwise proceed to next step.

10. Define:

Tan $Y_2' =$ Tan Y_2, $D_2' = D_2$, and $H' = H$ for the preceding plane for which Tan V_2 is greater than or equal to Tan V_2 for this plane.

Calculate:

$$R = (H + h_a + h_u - 3)\,\text{Tan } Y_2'$$

$$S = \left(\frac{H - H'}{D_2 - D_2'}\right) \cdot D_2 - H$$

$T=H+h_a+h_u-3$

$\omega_s'=\frac{1}{2}\omega\left[(L_p+2R)/2R, T/R\right]$

$\omega_s=\frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, T/D_2\right]$

or $\omega_s=\frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_u= \omega(\epsilon, ^S/d)$.

Transfer to step 14 below.

11. If Tan V_2 for any preceding plane is greater than Tan V_1 for this plane, proceed to the next step. Otherwise transfer to step 13 below.

12. Define:

Tan V_2'=Tan V_2, $D_2'=D_2$ and $H'=H$ for the preceding plane for which Tan V_2 is greater than Tan V_1 for this plane.

Calculate:

$R=(H+h_a+\frac{1}{2}h_u-3)\text{Tan } V_2'$

$S=\left(\frac{H-H'}{D_2-D_2'}\right)\cdot D_2-H$ or $S=h_a-3$ whichever is larger.

$T=H+h_a+\frac{1}{2}h_u-3$

$\omega_s'=\frac{1}{2}\omega\left[(L_p+2R)/2R, T/R\right]$

$\omega_s=\frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, T/D_2\right]$

or

$\omega_s=\frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_u=\omega(\epsilon, S/d)$

Transfer to step 14 below.

13. Calculate:

$\omega_s'=\frac{1}{2}\omega\left[(L_p+2D_1)/2D_1, (\text{Tan } V_1)^{-1}\right]$

or $\omega_s' = 0$ if $D_1 = 0$.

$\omega_s = \frac{1}{2}\omega\left[(L_p + 2D_2),\ (\mathrm{Tan}\ V_2)^{-1}\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_u = \omega\left[\epsilon, (h_a - 3)/d\right]$.

Proceed to next step.

14. Calculate:

$T = h_a + h_u - 3$

$\omega_u'' = \omega(\epsilon, T/d)$

$$C_1 = \left[B_{ws}(X_o, \omega_s) - B_{ws}(X_o, \omega_s')\right]\left[G_s(\omega_u'') - G_s(\omega_u)\right] S_w(X_e) E(J) \times B_w(X_i, 3)$$

or

$$C_1 = \left[B_w(X_o, H'') - B_{ws}(X_o, \omega_s')\right]\left[G_s(\omega_u'') - G_s(\omega_u)\right] S_w(X_e) E(J) B_w(X_i, 3)$$

if $\omega_s = \frac{1}{2}$, where $H'' = H + h_a + \frac{1}{2}h_u - 3$ or $H'' = 3$ whichever is algebraically larger.

Proceed to step D.

D. Determine wall-scattered components through detector story wall, C_2' and C_2''.

1. If $H - 3 \leq 0$ proceed to the next step. Otherwise transfer to step 5 below.

2. If $H + \frac{1}{2}h_a - 3 \leq 0$ proceed to the next step. Otherwise, transfer to step 5 below.

3. If H for any preceding plane is algebraically smaller than H for this plane, set $C_2' = C_2'' = C_3 = C_3' = C_4 = C_5 = C_5' = 0$ and proceed to the next plane (Step B). Otherwise proceed to the next step.

4. Calculate:

$\omega_s' = \frac{1}{2}\omega\left[(L_p+2D_1)/2D_1, (\text{Tan } W_1)^{-1}\right]$ or $W_s' = 0$ if $D_1 = 0$.

$\omega_s = \frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, (\text{Tan } W_2)^{-1}\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_u' = \omega(\epsilon, -H/d)$.

$\omega_1 = 1$.

Transfer to step 13 below.

5. If Tan T_2 for any preceding plane is negative or is larger than or equal to Tan T_2 for this plane, proceed to the next step. Otherwise transfer to step 8 below.

6. If Tan W_2 for any preceding plane is larger than or equal to Tan W_2 for this plane, set $C_2' = C_2'' = C_3 = C_3' = 0$ and transfer to step F. Otherwise proceed to the next step.

7. Define:

Tan W_2' = Tan W_2, $D_2' = D_2$ & $H' = H$ for the preceding plane for which Tan T_2 is larger than or equal to Tan T_2 for this plane.

Calculate:

$R = (H+h_a-3)\text{Tan } W_2'$

$S = \left(\frac{H-H'}{D_2-D_2'}\right) \cdot D_2 - H$

$T = H+h_a-3$

$\omega_s' = \frac{1}{2}\omega\left[(L_p+2R)/2R, T/R\right]$

$\omega_s = \frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, T/D_2\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_u' = \omega(\epsilon, S/d)$

$\omega_1 = 1.$

Transfer to step 13 below.

8. If Tan T_2 for any preceding plane is larger than Tan T_1 for this plane, proceed to the next step. Otherwise transfer to step 11 below.

9. Define:

Tan $T_2' = \text{Tan } T_2$, $D_2' = D_2$, and $H' = H$ for the preceding plane for which Tan T_2 is larger than Tan T_1 for this plane.

Calculate:

$R = (H + \frac{1}{2}h_a - 3)\,\text{Tan } T_2'$

$S = \left(\frac{H - H'}{D_2 - D_2'}\right) : D_2 = H$

$T = H + \frac{1}{2}h_a - 3$

$\omega_a' = \frac{1}{2}\omega\left[(L_p + 2R)/2R,\ T/R\right]$

$\omega_a = \frac{1}{2}\omega\left[(L_p + 2D_2)/2D_2,\ T/D_2\right]$

or $\omega_a = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

Proceed to next step.

10. If $S \leq -3$ then $\omega_u' = 1$ and $\omega_1 = \omega(\epsilon, 3/d)$.

If $0 > S > -3$ then

$\omega_u' = 1$ and

$\omega_1 = \omega(\epsilon, -S/d).$

If $S = 0$ then $\omega_u' = \omega_1 = 1.$

If $S > 0$ then

$\omega_u' = \omega(\epsilon, S/d)$ and

$\omega_1 = 1.$

Transfer to step 13 below.

11. Calculate:

$$\omega'_s = \tfrac{1}{2}\left[(L_p+2D_1)/2D_1, (\mathrm{Tan}\ T_1)^{-1}\right]$$

or $\omega'_s = 0$ if Tan $T_1 = 0$.

$$\omega_s = \tfrac{1}{2}\omega\left[(L_p+2D_2)/2D_2, (\mathrm{Tan}\ T_2)^{-1}\right],$$

or $\omega_s = \tfrac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

Proceed to next step.

12. If $H < 0$ then

$$\omega'_u = \omega(\epsilon, -H/d)$$

$$\omega_1 = 1.$$

If $H = 0$ then

$$\omega'_u = \omega_1 = 1.$$

If $0 < H < 3$ then

$$\omega'_u = 1$$

$$\omega_1 = \omega(\epsilon, H/d).$$

If $H \geq 3$ then

$$\omega'_u = 1$$

$$\omega_1 = \omega(\epsilon, 3/d).$$

Proceed to the next step.

13. Calculate:

$$\omega_u = \omega\left[\epsilon, (h_a - 3)/d\right].$$

$$C'_2 = \left[B_{ws}(X_c, \omega_s) - B_{ws}(X_c, \omega'_s)\right]\left[G_s(\omega_u) - G_s(\omega'_u)\right] S_w(X_e) E(J) B_w(X_i, 3),$$

$$C''_2 = \left[B_{ws}(X_c, \omega_s) - B_{ws}(X_c, \omega'_s)\right] G_s(\omega_1)\ S_w(X_e) E(J) B_w(X_i, 3)$$

or if $\omega_s = \tfrac{1}{2}$, replace $B_{ws}(X_c, \omega_s)$ above with $B_w(X_e, H)$ or with $B_w(X_c, 3)$ if $H < 3$.

and calculate as indicated. Proceed to step <u>E.</u>

<u>E.</u> Determine direct (unscattered) radiation through detector story wall, C_3.

<u>1.</u> If Tan $S_2 \leq 0$ for any preceding plane, set $C_3 = C_3' = 0$ and transfer to step <u>F.</u> Otherwise proceed to next step.

<u>2.</u> If Tan $R_1 \geq$ Tan S_2 set $C_3 = C_3' = 0$ and transfer to step <u>F.</u> Otherwise proceed to next step.

<u>3.</u> If Tan S_2 for any preceding plane is greater than Tan S_2 for this plane, set $C_3 = C_3' = 0$ and transfer to step <u>F.</u> Otherwise proceed to the next step.

<u>4.</u> If Tan S_2 for any preceding plane is greater than Tan S_1 for this plane, replace Tan S_1 of this plane with Tan S_2 of the preceding plane and proceed to the next step. Otherwise proceed directly to the next step.

<u>5.</u> If Tan $R_1 >$ Tan S_1, set $\eta = (\text{Tan } R_1)^{-1}$.
If Tan $R_1 \leq$ Tan S_1, set $\eta = (\text{Tan } S_1)^{-1}$.
Proceed to the next step.

<u>6.</u> Calculate:

$$\omega_1' = \omega\left[\epsilon, (\text{Tan } S_2)^{-1}\right]$$

or $\omega_1' = 1$ if this is the last plane from Item 20, FOSDIC form.

$$\omega_1 = \omega(\epsilon, \eta)$$

$$C_3 = B_w(X_e, H)\left[G_d(\omega_1, H) - G_d(\omega_1', H)\right]\left[1 - S_w(X_e)\right] B_w(X_i, 3)$$

If the detector is above window sill level, calculate:

$$C_3' = B_w(0, H)\left[G_d(\omega_1, H) - G_d(\omega_1', H)\right] B_w(X_i, 3)$$

Proceed to step <u>F.</u>

F. Determine the wall-scattered component from the story below, C_4.

1. If $H-3 \leq 0$ for this plane set $C_4=C_5=C_5'=0$ and proceed to the next plane (step B.). Otherwise proceed to the next step.

2. If $H-3 \leq 0$ for any preceding plane, except for the first plane, set $C_4=C_5=C_5'=0$ and proceed to the next plane (step B.). Otherwise proceed to the next step.

3. If $H-3 > 0$ for the first plane, proceed to the next step. If $H-3 \leq 0$ for the first plane, make the following re-definitions to be used in steps F and G only:

   a. $d_{new} = d_{old} + D_2$ where D_2 is for the first contaminated plane.

   b. Re-number the contaminated planes after deleting the first.

   c. Re-calculate D_1 and D_2 values for the planes.

   d. Re-evaluate ϵ and the quantities defined in steps A and B. Proceed to the next step.

4. If $H - \frac{1}{2}h_i - 3 \leq 0$ proceed to the next step. Otherwise transfer to step 7 below.

5. If H for any preceding plane is smaller than H for this plane, set $C_4=0$ and transfer to step G. Otherwise proceed to the next step.

6. Calculate:

   $\omega_s' = \frac{1}{2}\omega \left[(L_p+2D_1)/2D_1, (\mathrm{Tan}\ X_1)^{-1}\right]$

   or $\omega_s' = 0$ if Tan $X_1 = 0$.

   $\omega_s = \frac{1}{2}\omega \left[(L_p+2D_2)/2D_2, (\mathrm{Tan}\ X_2)^{-1}\right]$

   or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

   $\omega_1'' = \omega(\epsilon, H/d)$.

   Transfer to step 14 below.

7. If Tan U_2 for a preceding plane is negative or larger than or equal to Tan U_2 for this plane, proceed to the next step. Otherwise transfer to step 10 below.

8. If Tan X_2 for any preceding plane is larger than or equal to Tan X_2 for this plane, set $C_4 = 0$ and transfer to step G. Otherwise proceed to the next step.

9. Define:

Tan X'_2 = Tan X_2, $D'_2 = D_2$, and $H'_2 = H_2$

for the preceding plane for which Tan X_2 is larger than or equal to Tan X_2 for this plane.

Calculate:

$R = (H-3)\text{Tan } X'_2$

$$S = H - \left(\frac{H-H'}{D_2-D'_2}\right) \cdot D_2$$

$T = H - 3$

$\omega'_s = \frac{1}{2}\omega\left[(L_p+2R)/2R, T/R\right]$

$\omega_s = \frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, T/D_2\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega''_1 = \omega(\epsilon, S/d)$.

Transfer to step 14 below.

10. If Tan U_2 for a preceding plane is greater than Tan U_1 for this plane, proceed to the next step. Otherwise transfer to step 12 below.

11. Define:

Tan U'_2 = Tan U_2, $D'_2 = D_2$, and $H' = H$

for the preceding plane for which Tan U_2 is larger than Tan U_1 for this plane.

Calculate:

$R = (H - \frac{1}{2}h_1 - 3)\text{Tan } U_2'$.

$S = H - \left(\frac{H-H'}{D_2 - D_2'}\right) \cdot D_2$ or $S = h_1 + 3$, whichever is smaller.

$T = H - \frac{1}{2}h_1 - 3$.

$\omega_s' = \frac{1}{2}\omega\left[(L_p+2R)/2R, T/R\right]$.

$\omega_s = \frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, T/D_2\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

$\omega_1'' = \omega(\epsilon, S/d)$

Transfer to step 14 below.

12. Calculate:

$\omega_s' = \frac{1}{2}\omega\left[(L_p+2D_1)/2D_1, (\text{Tan } U_1)^{-1}\right]$

or $\omega_s' = 0$ if $\text{Tan } U_1 = 0$.

$\omega_s = \frac{1}{2}\omega\left[(L_p+2D_2)/2D_2, (\text{Tan } U_2)^{-1}\right]$

or $\omega_s = \frac{1}{2}$ if this is the last plane from Item 20, FOSDIC form.

Proceed to the next step.

13. If $H - h_1 - 3 < 0$

$\omega_1'' = \omega(\epsilon, H/d)$

If $H - h_1 - 3 \geq 0$

$\omega_1'' = \omega\left[\epsilon, (h_1+3)/d\right]$

Proceed to the next step.

14. Calculate:

$\omega_1 = \omega(\epsilon, 3/d)$.

$$C_4 = \left[B_{ws}(X_e, \omega_s) - B_{ws}(X_e, \omega_s')\right]\left[G_s(\omega_1'') - G_s(\omega_1)\right] S_w(X_e) \times E(J)\, B_w(X_i, 3)$$

or

$$C_4 = \left[B_w(X_e,H'') - B_{ws}(X_e,\omega_s')\right]\left[G_s(\omega_1'') - G_s(\omega_1)\right] S_w(X_e)E(J)B_w(X_1,3)$$

if $\omega_s = \frac{1}{2}$, where $H'' = H - \frac{1}{2}h_1 - 3$ or $H'' = 3$ whichever is algebraically larger. Proceed to step G.

G. Determine the direct (unscattered) component from the story below, C_5.

1. If ϵ and the quantities defined in steps A and B above have been re-evaluated in step F. 3 above, use the re-evaluated values in the following.

2. If $\mathrm{Tan}\ S_2 \leq \mathrm{Tan}\ R_2$

   or $\mathrm{Tan}\ S_1 \geq \mathrm{Tan}\ R_1$

   set $C_5 = C_5' = 0$ and proceed to the next plane (step B).

   Otherwise proceed to the next step.

3. If $\mathrm{Tan}\ S_2 \sim \mathrm{Tan}\ R_2$ for any preceding plane, replace $\mathrm{Tan}\ S_1$ for this plane with the largest $\mathrm{Tan}\ S_2$ for the preceding planes and proceed to the next step.

   Otherwise proceed directly to the next step.

4. Set $\eta = (\mathrm{Tan}\ R_1)^{-1}$ or $\eta = (\mathrm{Tan}\ S_2)^{-1}$ whichever is larger.

   Set $\eta' = (\mathrm{Tan}\ R_2)^{-1}$ or $\eta' = (\mathrm{Tan}\ S_1)^{-1}$ whichever is smaller.

   Proceed to the next step.

5. Calculate:

$$\omega_1 = \omega(\epsilon,\eta)$$

$$\omega_1'' = \omega(\epsilon,\eta')$$

$$C_5 = B_w(X_e,H'')\left[G_d(\omega_1'',H) - G_d(\omega_1,H)\right]\left[1-S_w(X_e)\right] B_w(X_1,3)$$

where $H'' = H - \frac{1}{2} h_1 - 3$ or $H'' = 3$ whichever is algebraically larger.

If there are apertures in the wall of the story below, calculate:

$$C_5' = B_w(0,H) \left[G_d(\omega_1'',H) - G_d(\omega_1,H) \right] B_w(X_1,3)$$

Proceed to next plane (step B).

H. Determine the skyshine component from the story above, C_6.

1. If this is the top story or IRF = 1, set $C_6 = C_6' = 0$ and transfer to step I. Otherwise proceed to next step.

2. Define Tan S_1' to be the algebraically smallest Tan S_1 from the subset of negative Tan S_1 from the set of Tan S_1 for all contaminated planes on this side of the building. If Tan S_1' does not exist there is no shielding of skyshine.

3. If $(-\text{Tan } S_1') < d/(h_a - 3)$, set $\eta = (-\text{Tan } S_1')^{-1}$
   If $(-\text{Tan } S_1') \geq d/(h_a - 3)$ or if Tan S_1' does not exist, set $\eta = (h_a - 3)/d$
   Proceed to next step.

4. Set $\eta'' = (h_a + h_u - 3)/d$
   Proceed to next step.

5. If $\eta \geq \eta''$ set $C_6 = C_6' = C_7 = C_7' = 0$ and transfer to step J.
   Otherwise proceed to the next step.

6. Calculate the difference $D_2 - D_1$ for each plane preceding the one for which $\left|-\text{Tan } S_1'\right| < d/(h_a - 3)$.

If this relation is not satisfied by any plane, or if Tan S_1' does not exist, calculate $D_2 - D_1$ for all planes.

Proceed to next step.

7. Let $H' = \left[\sum H(D_2 - D_1)\right] / \sum (D_2 - D_1)$

where the summations are taken over all planes for which differences were calculated in step 6 above.

Proceed to next step.

8. Calculate:

$\omega_u'' = \omega(\epsilon, \eta'')$

$\omega_u = \omega(\epsilon, \eta)$

$C_6 = B_w(X_c, H'') \left[G_a(\omega_u'') - G_a(\omega_u)\right] \left[1 - S_w(X_c)\right] B_w(X_i, 3)$

where $H'' = H' + h_a + \frac{1}{2}h_u - 3$ or $H'' = 3$, whichever is algebraically larger.

If there are apertures in the wall of the story above, calculate:

$C_6' = B_w(0, H'') \left[G_a(\omega_u'') - G_a(\omega_u)\right] B_w(\lambda_i, 3)$

where $H'' = H'$ or $H'' = 3$, whichever is algebraically larger.

Proceed to step I.

I. Determine the skyshine component from the detector story, C_7.

1. If Tan S_1' exists set $\eta' = (-\text{Tan } S_1')^{-1}$

Proceed to next step.

If Tan S_1' does not exist, set $\omega_u' = 1$.

Transfer to step 4 below.

2. If $\eta' \geq (h_a-3)/d$ set $C_7=0$ and transfer to step J.
Otherwise proceed to next step.

3. Calculate:

$$\omega_u' = \omega(\epsilon, \eta').$$

Proceed to next step.

4. Calculate the difference $D_2 - D_1$ for every plane preceding the one giving rise to Tan S_1' and proceed to the next step. If Tan S_1' does not exist, let $H'=H'$ from step H.7. above and transfer to step 6 below.

5. Let $H' = \left[\sum H(D_2-D_1)\right] / \sum(D_2-D_1)$ or $H'=3$, whichever is algebraically larger, where the summations are taken over all planes for which differences were calculated in step 4 above.

6. Calculate:

$$\omega_u = \omega\left[\epsilon, (h_a-3)/d\right]$$

$$C_7 = B_w(X_c, H') \left[G_a(\omega_u) - G_a(\omega_u')\right]\left[1-S_w(X_c)\right] B_w(X_i, 3).$$

If there are windows in the adjacent story wall, calculate:

$$C_7' = B_w(0, H') \left[G_a(\omega_u) - G_a(\omega_u')\right] B_w(X_i, 3).$$

Proceed to step J.

J. Determine the total ground contribution, C_g', from this side.

A_u = area fraction of apertures in wall of story above.

A_p = area fraction of apertures in detector story wall

$A_a = \dfrac{h_a A_p}{h_a - 3}$ = area fraction of apertures above detector on detector story.

A_l = area fraction of apertures in wall of story below.

Case 1. Detector is below aperture sill level in detector story wall.

$$C_g' = P\left[B_o'(X_o')\left[A_u C_6' + (1-A_u)\ (C_6+\sum C_1)\right] + A_a C_7' + (1-A_a)\ C_7 + \sum\left[(1-A_a)\ C_2' + C_2'' + C_3\right] + B_o(X_f)\sum\left[A_1 C_5' + (1-A_1)(C_5+C_4)\right]\right],$$

where the summations are taken over the contributing contaminated planes.

Case 2. Detector is above aperture sill level in detector story wall.

$$C_g' = P\left[B_o'(X_o')\left[A_u C_6' + (1-A_u)(C_6 +\sum C_1)\right] + A_p(\sum C_3' + C_7') + (1-A_p)\left[\sum(C_2'+C_2''+C_3) + C_7\right] + B_o(X_f)\sum\left[A_1 C_5' + (1-A_1)\ (C_5 + C_4)\right]\right],$$

where the summations are taken over the contributing contaminated planes.

Case 3. No apertures on any or all stories.

Simply put the appropriate A values equal to zero in either of the equations above.

K. Determine the Total Ground Contribution from all Sides.

$$C_g = \sum C_g'$$

where the summation is taken over the four sides of the building.

3. <u>Numerical Example, Ground Contributions</u>

Sample calculations using the recommended procedures are given for the fourth floor, side D, of the building described in TABS 3 and 4.

a. Establishment of Contaminated Planes

(1.) Side A

Plane 1: $D_1=0$, $D_2=990$, $H=33$

$L_t = 140$

(2.) Side B

Plane 1: $D_1=0$, $D_2=20$, $H=33$

Plane 2: $D_1=20$, $D_2=100$, $H=21$

Plane 3: $D_1 = 100$, $D_2 = 1090$, $H=33$

$L_t = 80$

(3.) Side C

Plane 1: $D_1=0$, $D_2=80$, $H=3$

Plane 2: $D_1=80$, $D_2=1070$, $H=33$

$L_t = 60$

(4.) Side D

Plane 1: $D_1=0$, $D_2=10$, $H=3$

Plane 2: $D_1=10$, $D_2=30$, $H=33$

Plane 3: $D_1=30$, $D_2=110$, $H=21$

Plane 4: $D_1=110$, $D_2=1100$, $H=33$

$L_t = 70$

For side D, $d = 35$.

$L_t = 70$

$L_p = 60$

$\epsilon = .857$

$p = .318$

IRF = 0

b. Ground Contribution Calculations

(1.) Plane 1

(a) Calculate C_1

$\omega_s' = 0$

$\omega_s = \frac{1}{2}\omega\left[(60+20)/20,\ 15/10\right] = .175$

$\omega_u = \omega\left[.857, .2\right] = .81$

$\omega_u'' = \omega\left[.857,\ .486\right] = .57$

$C_1 = \left[.0092 - 0\right] \times \left[.35 - .205\right] \times .63 \times 1.411 \times .60 = .00071$

(b) Calculate C_2' and C_2''

$\omega_s' = 0$

$\omega_s = \frac{1}{2}\omega\left[(60+20)/20,\ 5/10\right] = .345$

$\omega_1' = 1$

$\omega_1 = \omega(.857, .0857) = .92$

$\omega_u = \omega(.857,\ .2) = .81$

$C_2' = \left[.028 - 0\right] \times \left[.205 - 0\right] \times .63 \times 1.411 \times .60 = .00306$

$C_2'' = (.028) \times (.093) \times (.63) \times (1.411) \times .60 = .001388$

(c) Calculate C_3 and C_3'

$\eta = 3/35 = .0857$

$\omega_1' = \omega(.857,\ .0666) = .935$

$\omega_1 = \omega(.857,\ .0857) = .92$

$C_3 = .25 \times \left[.36 - .30\right] \times .37 \times .60 = .00333$

$C_3' = 1 \times \left[.36 - .30\right] \times .60 = .0360$

$C_4 = C_5 = C_5' = 0$

(2.) Plane 2

(a) Calculate C_1.

Tan V_2 for this plane equal to Tan V_2 for the preceding plane.

$R = (33 + 10 + 10 - 3) \times .5 = 25$

$S = \left(\frac{30}{20}\right) \times 30 - 33 = 12$

$T = 33 + 10 + 10 - 3 = 50$

$\omega_s' = \frac{1}{2}\omega\left[(60 + 50)/50,\ 2.0\right] = .11$

$\omega_s = \frac{1}{2}\omega\left[(60 + 60)/60,\ 1.67\right] = .13$

$\omega_u = \omega(.857,\ .343) = .68$

$T = 17$

$\omega_u'' = \omega(.857,\ .486) = .57$

$C_1 = \left[.0034 - .0019\right] \times \left[.35 - .282\right] \times .63 \times 1.411 \times .60 = .0000544$

(b) Calculate C_2' and C_2''

Tan T_2 for the preceding plane is greater than Tan T_2 for this plane.

Tan W_2 for a preceding plane is greater than Tan W_2 for this plane.

$C_2' = C_2'' = C_3 = C_3' = 0$

(c) Calculate C_4.

$d = 45,\ \epsilon = .667$

Re-evaluate the quantities defined in steps A and B.

$\omega_s' = 0$

$\omega_s = \frac{1}{2}\omega\left[(60 + 40)/40,\ 1.25\right] = .19$

$\omega_1'' = \omega(.667,\ .289) = .69$

$\omega_1 = \omega(.667,\ .0667) = .925$

$C_4 = \left[.0092 - 0\right] \times \left[.290 - .082\right] \times .63 \times 1.391 \times .60 = .001006$

(d) Calculate C_5 and C_5'

$C_5 = C_5' = 0.$

(3) Plane 3.

(a) Calculate C_1.

$\omega_s' = \frac{1}{2}\omega\left[(60 + 60)/60,\ 33/30\right] = .20$

$\omega_s = \frac{1}{2}\omega\left[(60 + 220)/220,\ 33/110\right] = .38$

$\omega_u = \ (.857,\ .2) = .81$

$T = 17$

$\omega_u'' = \omega(.857,\ .486) = .57$

$C_1 = \left[.053 - .0092\right] \times \left[.350 - .205\right] \times .63 \times 1.411 \times .60 = .00339$

(b) Calculate C_2' and C_2''.

$R = (21 + 5 - 3) \times 2 = 46$

$S = \frac{18}{100} \times 110 - 21 = -1.2$

$T = 21 + 5 - 3 = 23$

$\omega_s' = \frac{1}{2}\omega\left[(60 + 92)/92,\ 23/46\right] = .325$

$\omega_s = \frac{1}{2}\omega\left[(60 + 220)/220,\ 23/110\right] = .415$

$\omega_u' = 1$

$\omega_1 = \omega(.857,\ .0343) = .967$

$\omega_u = \omega(.857,\ .2) = .81$

$C_2' = \left[.060 - .028\right] \times \left[.205 - 0\right] \times .63 \times 1.411 \times .60 = .00350$

$C_2'' = \left[.060 - .028\right] \times .037 \times .63 \times 1.411 \times .60 = .000631$

(c) Calculate C_3 and C_3'.

$C_3 = C_3' = 0$

(d) Calculate C_4.

$d = 45, \quad \epsilon = .667$

Use the re-evaluated values for the quantities defined in steps A and B.

$\omega_s' = \frac{1}{2}\omega\left[(60 + 40)/40,\ 13/20\right] = .30$

$\omega_s = \frac{1}{2}\omega\left[(60 + 220)/220,\ 13/110\right] = .45$

$\omega_1'' = \omega\left[.667,\ 13/45\right] = .69$

$\omega_1 = (.667,\ .0667) = .925$

$C_4 = \left[.085 - .028\right] \times \left[.290 - .082\right] \times .63 \times 1.391 \times .60 = .00623$

(e) Calculate C_5 and C_5'

$\eta = 21/(110 + 45) = .135$

$\eta' = 13/45 = .289$

$\omega_1 = \omega(.667,\ .135) = .85$

$\omega_1'' = \omega(.667,\ .289) = .69$

$H'' = 13$

$C_5 = .175 \times \left[.48 - .175\right] \times .37 \times .50 = .01185$

$C_5' = .72 \times \left[.48 - .175\right] \times .60 = .1318$

(4) Plane 4

(a) Calculate C_1.

$R = (33 + 10 + 5 - 3) \times 110\ /(21 + 10 + 5 - 3) = 150$

$S = 7$

$T = 33 + 10 + 5 - 3 = 45$

$\omega_s' = \frac{1}{2}\omega\left[(60 + 300)/300,\ 45/150\right] = .38$

$\omega_s = \frac{1}{2}$

$\omega_u = \omega(.857,\ .2) = .81$

$T = 17$

$\omega_u'' = \omega(.857,\ .486) = .57$

$H'' = 45$

$C_1 = \left[.105 - .053\right] \times \left[.35 - .205\right] \times .63 \times 1.411 \times .60 = .004019$

(b) Calculate C_2' and C_2''

$R = (33 + 5 - 3) \times 110/(21 + 5 - 3) = 167$

$S = \frac{12}{990} \times 110 - 33 = -19.6$

$T = 33 + 5 - 3 = 35$

$\omega_s' = \frac{1}{2}\omega\left[(60 + 334)/334,\ 35/167\right] = .41$

$\omega_s = \frac{1}{2}$

$\omega_1 = \omega(.857,\ .0857) = .92$

$\omega_u' = 1$

$\omega_u = \omega(.857,\ .2) = .81$

$C_2' = \left[.13 - .053\right] \times \left[.205 - 0\right] \times .63 \times 1.411 \times .60 = .00841$

$C_2'' = \left[.13 - .053\right] \times .093 \times .63 \times 1.411 \times .60 = .00382$

(c) Calculate C_3 and C_3'

$\text{Tan } S_1 = (110 + 35)/21 = 6.90$

$\eta = 3/35 = .0857$

$\omega_1' = 1$

$\omega_1 = (.857,\ .0857) = .92$

$C_3 = .13 \times \left[.09 - 0\right] \times .37 \times .60 = .00260$

$C_3' = .575 \times \left[.09 - 0\right] \times .60 = .03105$

(d) Calculate C_4.

$d = 45 \quad , \epsilon = .667$

Use the re-evaluated values for the quantities defined in steps **A** and **B**.

$R = (33 - 5 - 3) \times 110/(21 - 5 - 3) = 212$

$S = 13$

$T = 25$

$\omega_s' = \frac{1}{2}\omega\left[(60 + 424)/424,\ 25/212\right] = .45$

$\omega_s = \frac{1}{2}$

$\omega_1'' = \omega(.667,\ .289) = .69$

$\omega_1 = \omega(.667,\ .0667) = .925$

$H'' = 25$

$C_4 = \left[.145 - .085\right] \times \left[.290 - .082\right] \times .63 \times 1.391 \times .60 = .00656$

(e) Calculate C_5 and C_5'

$\text{Tan } S_1 = (45 + 110)/21 = 7.38$

$\eta = 3/45 = .0667$

$\eta' = (\text{Tan } S_1)^{-1} = .1355$

$\omega_1 = \omega(.667,\ .0667) = .925$

$\omega_1'' = \omega(.667,\ .1355) = .85$

$H'' = 25$

$C_5 = .145 \times \left[.124 - .09\right] \times .37 \times .60 = .001094$

$C_5' = .61 \times \left[.124 - .09\right] \times .60 = .01244$

(5) Calculate Skyshine Contribution.

(a) Calculate C_6 and C_6'.

$\text{Tan } S_1'$ does not exist.

$\eta = 7/35 = .2$

$\eta'' = 17/35 = .486$

$H' = (3 \times 10 + 33 \times 20 + 21 \times 80 + 33 \times 990)/(1100) = 31.9$

$\omega_u'' = \omega(.857, .486) = .57$

$\omega_u = \omega(.857, .2) = .81$

$H'' = 31.9 + 10 + 10 - 3 = 48.9$

$C_6 = .105 \times \left[.081 - .052\right] \times .37 \times .60 = .000676$

$C_6' = .49 \times \left[.081 - .052\right] \times .60 = .00853$

(b) Calculate C_7 and C_7'.

$\omega_u' = 1$

$\omega_u = \omega(.857, .2) = .81$

$C_7 = .13 \times \left[.052 - 0\right] \times .37 \times .60 = .00150$

$C_7' = .575 \times \left[.052 - 0\right] \times .60 = .01794$

(6) Calculate Total Contribution from Side D.

$A_n = \frac{(.20) \times (10)}{7} = .286$

$(.80) \times \sum C_1 = .00654.$

$\sum(.714 \times C_2' + C_2'' + C_3) = .02245$

$\sum\left[(.20) \times C_5' + (.80) \times (C_5 + C_4)\right] = .05023$

$C_8' = (.318) \times \Big[(.043) \times (.001706 + .000541 + .00654)$

$+ .00513 + .001071 + .02245 + (.061) \times (.05023)\Big]$

$C_8' = .0102$

D. Areaways

1. Present Method

Areaways are now considered in the NFSS only if they exceed 50 percent of the length of the adjacent wall. They are then counted as the first plane of contamination on that side and must be considered as a minimum of ten feet wide. In reality, only a limited number of areaways are that long or that wide.

2. Recommended Method

a. Procedure

An areaway in an otherwise unexposed basement will contribute a large part to the total reduction factor and therefore should be considered regardless of length. TAB 9 indicates how the reduction factor of an unexposed basement as described in Example 5.2 of Reference 5 is increased by the addition of an areaway. The reduction factor is increased approximately 6 percent by the addition of a five foot wide areaway adjacent to 50 percent of one exterior wall. This increase would be approximately 15 percent if the upper 1½' of the exterior wall adjacent to the areaway were windows. If there had been a 3'x7' door leading into this areaway, the reduction factor would have increased about 9 percent. A combination of the windows and door would increase the reduction factor by approximately 18 percent.

It is recommended that the portion of basement wall with an adjacent areaway be considered as the first story with the bottom of the areaway as the first plane of contamination and the normal grade level as the second plane. Contribution from this finite plane of contamination will be calculated by the EM method in which directional responses for direct and scattered radiation are differenced. The directional response for scattered radiation is then multiplied by a barrier reduction factor

for limited planes (EM Chart 9). The ratio of the areaway length to the wall length would be used to determine the percentage of this contribution to be used in the total wall contribution. The contribution from the upper story would be computed as recommended under Section A. Data for this calculation are available from Columns 70 - 76 of the Phase 2 DCF. Data regarding apertures in areaways are not collected in Phase 1 or 2 but, as indicated by the results in TAB 9, data should be gathered for new or modified structures.

b. <u>Chart Changes</u>

The calculation of areaway contribution is now handled by consideration as a contaminated plane; therefore, only Table 6 (Reference 1) is deleted. Tables are needed to represent Engineering Manual Chart 2 for wall barrier factor; Chart 5 for G_s and G_a directional responses; Chart 6 for G_d directional response; Chart 7 for wall-scatter factor; Chart 8 for shape factor; and Chart 9 for wall-scatter barrier factor.

c. <u>Functional Equations</u>

The basic equation for an areaway with no apertures in an otherwise unexposed basement, using symbols contained in Table 5 of Reference 3, is

$$ADOS = P_r \frac{L_a}{L} B_w(X_i, 3') \left[C_1 + C_2 + C_3 \right]$$

in which L_a = length of areaway, and

(1) when the detector is above the level of the areaway

$$C_1 = \left[G_s(\omega_1) + G_s(\omega_u) \right] S_w(X_e) \quad E(e) \quad B_{ws}(\omega_s, X_e)$$

$$C_2 = \Delta G_d \left[\cdot - S_w(X_e) \right] B_w(X_e, H)$$

$$C_3 = \Delta G_a(\omega) \left[1 - S_w(X_e) \right] B_w(X_e, H)$$

(2) when the detector is below the level of the areaway

$$C_1 = \Delta G_s(\omega)\ S_w(X_e)\ E\ (e)\ B_{ws}(\omega_s, X_e)$$

$$C_2 = 0$$

$$C_3 = \Delta G_a(\omega)\ \left[1 - S_w(X_e)\right]\ B_w(X_e, H)$$

d. Calculations

(1) Comments

(a) The calculation is made for the portion of basement wall adjacent to an areaway.

(b) The contribution from the story above the detector is calculated as recommended in Section A, Basement Exposure. In this calculation ignore the areaway.

(c) The level of the areaway if assumed to be located at the level of the basement floor.

(d) Areaway contribution is ignored when the basement exterior wall is exposed above grade.

(2) Symbols Used

D = distance from detector to exterior wall

XE = exterior mass thickness of wall adjacent to areaway

XI = interior wall mass thickness between detector and contributing wall (see Section E for determination of effective thickness)

L = length of this side of building

L_a = length of the areaway

P_r = ratio of length of side of building to the perimeter of building

HB = height of basement

HD = detector height above basement floor (3 ft)

HP1 = height of areaway (first plane) above first floor (will be negative)

HP2 = height of grade level (second plane) above first floor

HP3 = height of third plane above first floor

D1 = width of areaway measured along a perpendicular to building wall

D2 = distance from exterior wall to outer boundary of second plane (inner boundary of third plane)

D3 = distance from exterior wall to outer boundary of third plane

(For the location of these data on the Phase 1 and 2 Data Collection Forms see TAB 2)

(3) Detail Calculations

(a) Calculate the contribution from the adjacent wall.

1. The procedure is to enter the program in Section II. C. 2. d. (3) (a) for the Ground Contribution-Stories Above Grade with the following input data:

Ground Contribution Notation		Areaway Notation
d	=	D
X_e	=	XE
X_i	=	XI
L_t	=	2D
L_p	=	L
h_a	=	HB

$$\text{for first plane}\begin{cases} H & = & HD \\ D_1 & = & 0 \\ D_2 & = & D1 \end{cases}$$

$$\text{for second plane}\begin{cases} H & = & HD\text{-}HP2\text{-}HB \\ D_1 & = & D1 \\ D_2 & = & D2 \end{cases}$$

$$\text{for third plane}\begin{cases} H & = & HD\text{-}HP3\text{-}HB \\ D_1 & = & D2 \\ D_2 & = & D3 \end{cases}$$

Detector story = first

Aperture fraction $A_p = 0$

2. Perform the operations in (a), (b) A. and B. (definitions) D. (wall scatter adjacent), E (direct adjacent), I (skyshine adjacent). There will be a contribution only from the first plane. The data for the second and third planes are used to determine the amount of skyshine that is blocked.

3. Set $C_1 = C_7 = C'_7 = 0$, and perform the operations in J.
   Result: C'_g
   This is the total contribution through the adjacent wall assuming the areaway extends the full length of the wall.

4. $WAL1 = C_g' \times L_a/L$

(b) Compute the contribution through the first and second story walls below and above sill levels with the procedure in II. A. 2. d. (3)(c),(d) and (g). Neglect the areaway and set D1 = 0 for the second plane (grade level).
   Result: WAL3, WAL4, WAL5, WAL6

(c) The total contribution for this side is

$$WALDA = WAL1 + WAL3 + WAL4 + WAL5 + WAL6$$

(d) Compute the contribution from the other 3 sides following the procedure in II. A. 2. d. (3)

Result: WALDA, WALDB, WALDC, WALDD

(e) The total ground contribution is

WALD = WALDA + WALDB + WALDC + WALDD

3. Numerical Example

A sample calculation using the recommended procedures for areaway calculation is given for the areaway defined in TABS 3 and 4. The depth of the areaway is assumed to be at the level of the basement floor.

a. Data

$d = D = 70'$

$X_e = XE = 60$ psf

$X_i = XI = 20$ psf (zero in ground contribution procedure)

$L_t = 140'$

$L_p = 80'$

$L_a = 40'$

$h_a = HB = 13'$

$h_\ell = 0$

$hu = 10$

$HP1 = -13'$

$HP2 = 0$

$D1 = 5$

$D2 = \infty$

$A_p = 0$

$HD = 3'$

$$\text{1st plane} \begin{cases} H = 3+13-13 = 3' \\ D1 = 0 \\ D2 = 5' \end{cases}$$

$$\text{2nd plane} \begin{cases} H = 3-0-13 = -10' \\ D1 = 5' \\ D2 = \infty \end{cases}$$

b. <u>Calculation of Areaway Contribution</u>

(1) <u>Set up Tangent Values</u>

<u>A</u> $\tan R_1 = 70/3 = 23.3$

$\tan R_2 = 70/3 = 23.3$

		1st plane	2nd plane
<u>B</u>	$\tan S_1$	+23.3	-7.5
	$\tan S_2$	+25.0	$-\infty$
	$\tan T_1$	+ 0	-0.77
	$\tan T_2$	+0.77	$-\infty$
	$\tan U_1$	--	-0.385
	$\tan U_2$	$+\infty$	$-\infty$
	$\tan V_1$	0	+1.0
	$\tan V_2$	+0.278	$+\infty$
	$\tan W_1$	0	$+\infty$
	$\tan W_2$	+0.385	$+\infty$
	$\tan X_1$	--	-0.385
	$\tan X_2$	$+\infty$	$-\infty$
	$\tan Y_1$	0	+2
	$\tan Y_2$	+0.218	$+\infty$

(2) <u>Find Scattered Contribution</u>

<u>D</u> <u>11</u> $\omega_s' = \tfrac{1}{2}\left[\frac{80+0}{0},\ -\right] = 0$

$\omega_s' = \tfrac{1}{2}\left[(80+10)/10, 1.3\right] = \tfrac{1}{2}(0.416) = 0.208$

<u>12</u> $\omega_u' = 1.0$

$\omega_l = (80/140, 3/70) = (0.571, .0428) = .945$

<u>13</u> $\omega_u = (0.571, 10/70) = (0.571, .143) = .822$

$$C_2' = \left[Bws\ (60\theta, 0.208) - Bws\ (60\theta, 0)\right] \times$$

$$\left[G_s\ (0.822) - G_s(1.0)\right]\ Sw\ (60\#)\ E\ (.571)$$

$$= (0.0092-0)\ (0.195-0)\ (0.63)(1.37)$$

$C_2' = \underline{0.00155}$

$C_2'' = \left[Bws - Bws\right]\left[G_s(0.945)\right] \quad (0.63)\ (1.37)$

$= (0.0092)\ (0.072)\ (0.63)\ (1.37)$

$C_2'' = \underline{0.00057}$

C_1 = (see areaway functional equation) = $C_2' + C_2''$

$C_1 = 0.00155 + 0.00057 = \underline{0.00212}$

(3) <u>Find Direct Contribution</u>

<u>E</u> <u>5</u> $n = 1/23.3 = 0.0428$

<u>6</u> $\omega_1' = \omega(0.571, 1/25) = \omega(0.571, 0.04) = 0.949$

$\omega_1 = \omega(0.571, 0.0428) = 0.945$

$C_3 = B_w\ (60\#, 3')\ \left[G_d(0.945,\ 3') - G_d(0.949,\ 3'')\right] \times$

$(1 - Sw(60\#))$

to get the ΔG_d we use linear interpolation

$C_3 = (0.25)\ \left[\frac{0.949-0.945}{0.96-0.94} \times 0.08\right]\ (1-0.63)$

$= 0.25\ \ (0.004 \times 0.08/0.02)\ (0.37)$

$= 0.25\ (0.016)\ (0.37) = 0.00148$

C_2 (see areaway functional equation) = C_3 (above)

$\underline{C_2} = \underline{0.00148}$

(4) <u>Find Skyshine Contribution</u>

<u>H</u> <u>2</u> $\tan S_e' = -7.5$

<u>I</u> <u>1</u> $n' = -1/-7.5 = 0.1333$

<u>2</u> $n' \geq 10/70$

<u>3</u> $\omega_u' = (0.571,\ 0.1333) = 0.834$

<u>6</u> $\omega_u = (0.571,\ 0.143) = 0.823$

$G_7 = B_w(60\#, 3')\ \left[G_a(0.823) - G_a(0.835)\right]\ (1-0.63)$

$= 0.25\ (0.0505-0.0485)\ (0.37)$

$= 0.25\ (0.0020)\ (0.37)$

$G_7 = 0.000185$

C_3 (see areaway functional equation) = C_7 (above)

C_3 = <u>0.000185</u>

(5) <u>Find the total areaway dose</u>

$$ADOS = \frac{80}{440} \times \frac{40}{80} \times B_w(20\#, 3') \left[C_1 + C_2 + C_3\right]$$

$$= \frac{1}{11}(0.60)(0.00212+0.00148+0.000185)$$

$$= \frac{1}{11}(0.60)(0.003785) = \frac{1}{11}(0.002273)$$

<u>ADOS = 0.0002065</u>

For comparison, the basement calculation yielded:

WALD (no exposure) = 0.000158

WALD (5' exposure) = 0.00310

E. Interior Partition Effective Mass

1. Recommended Method

A Technical Operations Research model study (see Reference 6) of the effect of interior partitions on ground contribution verifies that the Engineering Manual method of handling interior partitions with azimuthal sectors is satisfactory. Since Phase 2 interior partition data are collected on a wall-by-wall basis and are not sufficiently detailed to permit the use of azimuthal sectors in calculating attenuation due to interior partitions, the azimuthal sectors that are inherent in the recommended changes are those defined by the exterior wall intersections. Consequently, the revised Computer Program will not treat interior partitions with the Engineering Manual method. It is therefore necessary to program instructions so that the Computer Program can interpret interior partition data. Corridor (or parallel) and cross partition mass thicknesses as well as their average spacing and general pattern are entered in the Phase 2 collection forms (Reference 7, page DCFI-24). The influence of the spacing of cross partitions in compartment geometry on dose rates was not investigated by Technical Operations Research. However, an approximate prescription can be formulated as follows: the spacing used in the experiment was such that if all cross partitions on one side of the corridor were rotated 90° and placed end-to-end, they would form a corridor type partition that would extend practically the entire length of the building. In other words, the smeared mass thickness of the cross partitions is nearly equal to their actual mass thickness. Some data are available for the computer to estimate smeared mass thicknesses. It is therefore recommended that:

a. Interior partitions between a detector and wall which have box or corridor geometries be assigned a mass thickness equal to the sum of the interior wall thicknesses.

b. Cross interior partitions be assigned a mass thickness equal to one-half the smeared mass thickness.

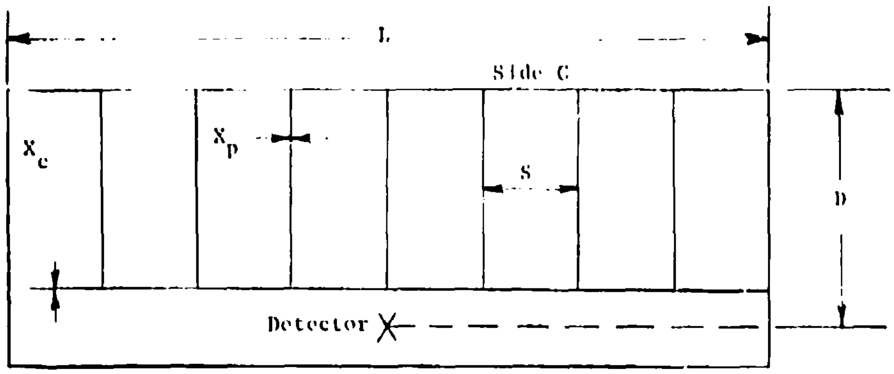
c. The total interior mass thickness be set equal to the sum of those calculated in a and b.

Consider, for example, the contribution from side C of a building of type I (Reference 7, page DCFI-25) shown in Figure P-2.

FIGURE P-2

PLAN OF BUILDING WITH 7 CROSS PARTITIONS

$X_c = 40$ psf, $X_p = 20$ psf, $L = 80'$, $D = 20'$, $S = 10'$



The smeared thickness of one cross partition is X_p D/L, and that for all cross partitions $(\frac{L}{S} - 1)$ is:

$$X_p)_{\text{smeared}} = \left[\frac{L}{S} - 1\right] X_p \frac{D}{L}$$

$$= \left[\frac{80}{10} - 1\right] (20) \left[\frac{20}{80}\right]$$

$$= 35 \text{ psf}$$

The total interior mass thickness for side C is:

$$X_i = X_c + \tfrac{1}{2} X_{p)smeared}$$
$$= 40 + \tfrac{1}{2}(35)$$
$$= 57.5 \text{ psf}$$

The same value can be used for the contribution from the left and right ends of the building in Figure P-2.

Unfortunately, it is not possible to determine from the Phase 2 data where the cross partitions are located, i.e., on sides A, B, C, and/or D. This information is needed in the calculation of $X_{p)smeared}$ (through the parameters D and L) and in the determination of the sides through which the radiation must penetrate interior partitions. For example, the computer should use $X_i=0$ rather than the above computed value for X_i for the radiation entering the side opposite Side C in Figure P-2.

An examination of the Phase 2 DCF's shows that each building type 1-4 (see column 69) with cross partitions may have non-zero entries for parallel partitions on 1-4 sides (see columns 58-65). Consequently, some scheme for interpreting the data is required in order to use the cross partition information in the calculations. The following conservative approach is recommended: the instruction a, b, c, or d to be programmed for each combination of building type and parallel partition configuration is indicated in Table P-I.

TABLE P-I

INTERIOR PARTITIONS - PROGRAM INSTRUCTIONS

Code Number for Building Type	1	2	3	4
Number of Walls with Parallel Partitions				
0	d	d	d	d
1	a	a	a	a
2	a	b	a	a
3	a	c	a	a
4	a	d	a	a

a. Assume that cross partitions are located on those sides with parallel partitions for which $S \leq L$. Set $X_i = 0$ for the sides with no parallel partitions. Use $X_i = X_c$ for sides with parallel partitions and no cross partitions.

b. If the walls with parallel partitions are opposite each other, assume that the cross partitions are located on these sides. Use the X_i computed for these sides on all four sides.

c. Assume that the cross partitions are located on the sides with parallel partitions opposite each other. Use $X_i = X_c$ for the third side with a parallel partition, and use $X_i = \frac{1}{2}X_{p)\text{smeared}}$ for the fourth side.

d. Assume that the cross partitions are located at the narrower ends of the building (i.e., they extend in a direction parallel with the longer sides) unless their

spacing S is greater than the length L of the shorter side. (If $S > L$, assume that they are on the other two sides.) Compute $X_{p)smeared}$ and add ½ this value to X_c for each side to obtain X_i for each of the four sides. (X_c is zero if a side has no parallel partition.)

2. Symbols Used

D = distance from detector to exterior wall

L = length of this wall

S = average spacing of cross partitions

X_c = total mass thickness of parallel partitions on a side

X_i = total interior mass thickness for a side

X_p = average mass thickness of one cross partition

$X_{p)smeared}$ = smeared mass thickness of cross partitions

F. Total Contribution

The total contribution (RF) for a building is determined by adding the contributions of Sections A through D for each story of a building.

$$\text{Protection Factor} = \frac{1}{RF}$$

It is recommended that the computer print-out indicate separate contributions for each wall through the solid portion and through the apertures.

G. Charts

In order to accomplish the calculations recommended above, Tables 2, 3, 4, 5, 6, and 8 are to be deleted from the computer program. Tables 1 and 7 will remain, whereas new tables are required for Chart 1 (Case 1), Chart 2, Chart 4, Chart 5 (G_s and G_a), Chart 6, Chart 7, Chart 8, and Chart 9 of the Engineering Manual (see Reference 3) and Chart 11 of the Shelter Design and Analysis Manual (see Reference 5). Charts are referred to as being Engineering Manual Charts in order to identify the "procedure," however the latest revision of all charts will be used whether they appear in Reference 2 or Reference 5.

Tables representing the required charts are included in TAB 10. The tabular values for height in Chart 2 and solid angle fraction in Charts 4 and 9 have logarithmic spacing (Log H goes from 0.5 to 3.0 in steps of 0.1 and Log ω from -3.0 to 0.0 in steps of 0.1). The computer will calculate solid angle fractions and round to the nearest Log ω.

In general, interpolation of these Charts is not required except for the directional response for direct radiation, G_d, for areaways. For this case, enter Table 6 with a height of 3 ft and use linear interpolation for the ω variable.

H. Shelter Area Factors

1. Background

Area factors are used to represent fractions of total floor areas in determining the S-AREA offering protection greater than a predetermined value. The area factors used in the present NBS-NFSS Computer Program are based on the extent of the area in PF Category 4-8 shelters which does not drop below PF 100. Under the revised criteria for marking shelters it has become of interest to ascertain the fraction of floor area that is above PF-40. Specifically, RTI was asked by OCD to determine in a preliminary way if the area factors in Table P-II are conservative or nonconservative. The single area factor in the Phase 1 NFSS Computer Program is indicated in parentheses under each PF category.

2. Recommended Area Factors

RTI has made contour plots of PF's throughout the first story of a windowless square building using the AE Guide procedure. Wall thicknesses were chosen to give center PF's of 55, 85, and 125 for PF Categories 2, 3, and 4, respectively. The fraction of the floor area that had a PF greater than 40 was then graphically determined, assuming no roof contribution. The results depended on the floor area and are shown in Figure P-3 for buildings in PF Category 2 (average center PF = 55). These area factors indicate that the entry of 0.4 in Table P-II for Category 2 with a minimum PF of $(PF)_c=40$ and the entry of 0.7 for PF Category 3 with $(PF)_c=40$ are conservative, i.e., underestimates. Next the influence of apertures was investigated by RTI personnel. Generally, the

TABLE P-II

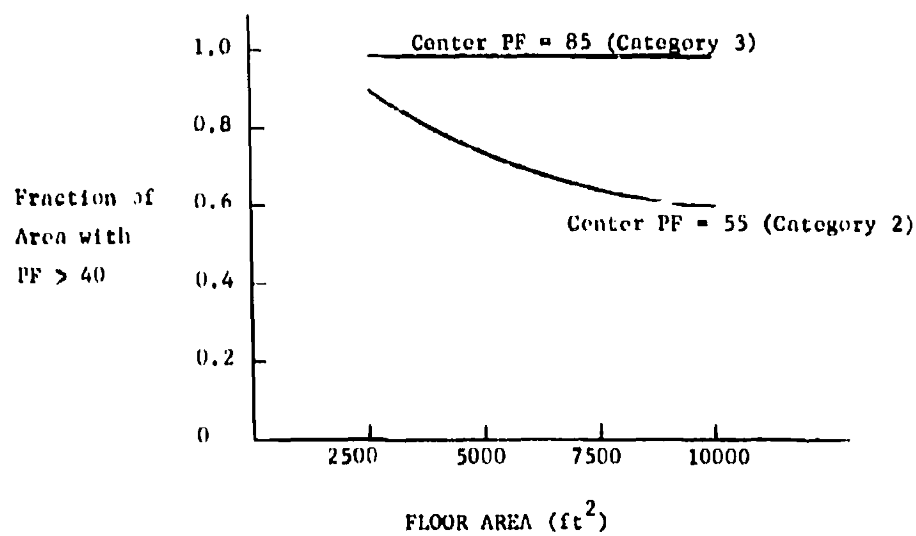
Table of Fractional Shelter Area with PF Greater than $(PF)_c$

(Received from OCD for Evaluation by RTI)

Shelter Category	8	7	6	5	4	3	2	1
(NFSS Phase 1 Area Factor)				(.7)	(.3)	(.5)	(.5)	
$(PF)_c$								
500	1.0	.5						
250	1.0	.8	.5					
150	1.0	.9	.8	.4				
100	1.0	1.0	.9	.7	.3			
70	1.0	1.0	.9	.8	.6	.3		
40	1.0	1.0	.9	.9	.8	.7	.4	
20	1.0	1.0	1.0	.9	.8	.8	.5	

FIGURE P - 3

Area Factor Dependence on Floor Area on the Fir ε Floor of a Windowless Building with No Roof Contribution



variation in area factor with increasing aperture percentage (up to 40 percent) was less than the variation with floor area from 2500 to 10,000 square feet. In summary, the results of RTI's preliminary investigation are reported in Table P-III. These area factors are believed to be conservative for the majority of cases.

3. Dependence of Area Factor on Source-Building Configuration

a. Interior Partitions

It is pointed out that values in Figure P-3 may not be appropriate for the use with buildings with interior partitions when the center PF is calculated with the partition barrier factor. In this case, the PF will make a rapid drop as one leaves the core area defined by the partitions (for example, see Table 8 of Reference 6). It is expected that the area factor for a core area should be larger than the area factor for a building with no interior partitions.

b. Roof Versus Ground Contribution

Another important consideration in determining area factors is the source location. In general, the center of the floor area is the safest place to be when the predominant radiation enters through the adjacent walls (equally from all sides). In this case an area factor of 0.7 means that the 30 percent of the floor area next to the walls should not be occupied. In contrast to this situation, the safest location is next to the wall when the predominant contribution comes from the roof or through the ceiling into the basement. In this case an area factor of 0.7 would mean that the central 30

TABLE P-III

Table of Fractional Shelter Area with PF Greater than $(PF)_c$

(RTI Recommendations - Ground Contribution Only)

Shelter Category $(PF)_c$	8	7	6	5	4	3	2	1
100	1.0	1.0	1.0	.9	.4			
40	1.0	1.0	1.0	1.0	1.0	1.0	.6	

percent of the floor area should be restricted. It is thus evident that the gradient of the PF contours in a building has opposite signs, depending on the source location. When both adjacent and roof contributions are present, the spatial variation of the PF is less pronounced due to the compensating effect of adding two distributions that vary in opposite senses. The computer program now assigns PF category on the basis of the protection factor calculated at the center of the shelter. Thus, if a shelter with its predominant contribution from the roof has a center PF of 100, it would be assigned to PF Category 4 (PF range 100-149) and should have a unity area factor. If its center PF were somewhat less than 100, it should also be assigned to Category 4 with its area factor reduced accordingly. This is of course not now done in the NFSS. In order to specify area factors that are accurate to 50 percent (e.g., 0.6 versus 0.9), it appears necessary to use a two-parameter table in which look-ups depend on floor area and relative roof contribution.

c. Floor Thickness

The PF variation across the floor also depends in a significant way on the floor thickness when the chief contribution arises from limited planes of contamination. For example, for a plane less than 300 feet wide, Tech Ops experimentally found that the dose rate at an upper story corner position in a windowless building with light floors ($X_f < 40$ psf) was 1.4 times that at the center position whereas it was 2.5 times greater than that at the center for thick floors ($X_f > 40$ psf). (See Table 42 of Reference 8.)

d. Apertures

A preliminary investigation indicated that the area factor depends to some extent on the percentage and location of apertures. These

investigations actually indicated an increase in the usable shelter area when apertures are added. For example, on the second floor of a 5000 square foot building with a center protection factor of 125, the fraction of the area having a protection factor greater than 100 is 0.43 with no apertures, and increases to 0.56 with 10 percent apertures (increased wall mass thickness to maintain center PF of 125).

Instead of restricting area along the exterior walls as is done in the case without apertures, the shelter area in a building with apertures is a complex function of exact aperture location as well as ground contribution (assuming no roof contribution). If roof contribution is also involved the boundaries of the shelter area are even more difficult to define.

4. Recommended Investigations

In view of the importance of identifying the maximum number of shelter spaces and the fact that the dose rate spatial variation is interdependent on several factors, it may be justifiable to use the NFSS Computer Program to calculate more than one PF for each shelter - one at the center, and one or more at the periphery along each building axis. It is expected that this information can be directly correlated in an elementary way with the correct area factor. This approach offers a way in which the conservatism in Table P-II can be removed with confidence.

It is recommended that a more extensive analysis of the area factors be made; however, in many cases the AE surveying the building, because of exact location of partitions, apertures, etc., will locate and limit useful shelter area.

REFERENCES

1. L. V. Spencer and C. Eisenhauer. Calculation of Protection Factors for The National Fallout Shelter Survey. National Bureau of Standards Report 7539, Washington: U. S. Department of Commerce, 3 July 1962.

2. Office of Civil Defense. Guide for Architects and Engineers. Washington: Office of Civil Defense, December 1961.

3. Office of Civil Defense. Design and Review of Structures for Protection From Fallout Gamma Radiation (Engineering Manual). Rev. ed.; Washington: Office of Civil Defense, 1 October 1961.

4. W. K. Grogan, E. L. Hill and D. T. Searls. Application of Statistical Sampling Procedures to Estimate Probable Error of NFSS Findings. Research Memorandum RM-81-4. Durham: Research Triangle Institute, Operations Research Division, 19 November 1962.

5. Office of Civil Defense. Shelter Design and Analysis. Rev. ed.; Washington: Office of Civil Defense, November 1962.

6. Albert W. Starbird, Joseph D. Velletri, Robert L. MacNeil, and John F. Batter. The Effect of Interior Partitions on the Dose Rate in a Multistory Windowless Building. Report No. TO-B 63-6. Burlington, Massachusetts: Technical Operations Research, 31 January 1963.

7. Department of the Army. Fallout Shelter Survey Instructions - Phase 2. Washington: Department of the Army, Office of the Chief of Engineers, 21 March 1962.

8. John F. Batter, Albert W. Starbird and Nancy-Ruth York. Final Report - The Effect of Limited Strips of Contamination on the Dose Rate in a Multi-Story Windowless Building. Report No. TO-B 62-58. Burlington, Massachusetts: Technical Operations, Inc., August, 1962.

TAB 1

Partial Basement Exposure Calculations*

(Engineering Manual and AE Guide **)

% Exposed	Area ft^2	20 psf walls EM	20 psf walls AE	80 psf walls EM	80 psf walls AE	120 psf walls EM	120 psf walls AE
		Reduction Factor					
0%	100	.020	.021	.009	.009	.004	.003
	500	.045	.045	.020	.021	.009	.009
	5000	.062	.060	.026	.028	.012	.012
	20000	.060	.051	.024	.021	.011	.009
18.75%	100	.035	.128	.015	.038	.007	.015
	500	.081	.128	.035	.045	.015	.019
	5000	.082	.103	.034	.039	.015	.018
	20000	.058	.077	.023	.028	.010	.012
37.5%	100	.064	.230	.028	.065	.012	.026
	500	.100	.210	.043	.070	.024	.028
	5000	.097	.150	.040	.051	.017	.022
	20000	.067	.104	.027	.034	.011	.014
75%	100	.448	.450	.130	.120	.053	.050
	500	.343	.375	.102	.120	.042	.047
	5000	.200	.230	.062	.073	.026	.032
	20000	.109	.156	.037	.048	.015	.020

* 8 ft Basement, 10 ft first story, 0 psf 1st floor slab, Detector 3 ft above basement floor.

** Using Charts 7.1 and 7.2 of Shelter Design and Analysis.

TAB 2

Location of Data on Phase 1 FOSDIC's and Phase 2 DCF's Necessary to Make EM Calculations

Basement Exposure — **Data Location**

	Phase 1		Phase 2	
Code	**Sec.**	**Item**	**Sec.**	**Col**
D			B	44-49
XE	23	Ext.Wall(a-d)		
XEP	23	Ext.Wall(q-t)		
XEQ	23	Ext.Wall($\bar{c}$-$\bar{f}$)		
XPR	22	First (b)		
XPS	22	Upper (c)		
XI	23	Int.Wall (m-p)		
AP	23	Apertures (i-l)		
APP	23	Apertures (u-x)		
APQ	23	Apertures ($\bar{g}$-$\bar{j}$)		
P	17	Ext.Walls (a-b)		
L	17	Ext. Walls (a-b)		
HB	18	Bsmt. Ht. (b)		
HF	18	First Ht. (c)		
HS	18	Upper Ht. (d)		
HD (Assumed 3')				
HSB			B	54-57
HSF			B	54-57
HSS			B	54-57
HP	20	A,B,C, or D Height		
D1	20	A,B,C, or D Width		
D2	20	A,B,C, or D Width		

(Continued.)

Roof Contribution		Data Location		
	Phase 1			Phase 2
Code	Sec.	Item	Sec.	Col.
A	17	Ext.Wall (a)		
B	17	Ext.Wall (b)		
CA			B	50-51
CB			B	52-53
DA			B	44-46
DB			B	47-49
H	18	Total Bldg. (a)		
HBS	19	Setback Ht. (e,j,o)		
HD (Assumed 3')				
HP	20	A,B,C, or D Height		
SA	20	Dist. to Face (f,k,p)		
SB	20	Dist. to Face (g,l,q)		
SC	20	Dist. to Face (h,m,r)		
SD	20	Dist. to Face (i,n,s)		
W_c	20	A,B,C, or D Width		
X_o	22	Roof & Floors (a-d)		
XIA	23	Int. Wall $(m,y,\bar{k},\bar{\bar{a}})$		
XIB	23	Int. Wall $(n,z,\bar{e},\bar{\bar{b}})$		
XIC	23	Int. Wall $(o,\bar{a},\bar{m},\bar{\bar{c}})$		
XID	23	Int. Wall $(p,\bar{b},\bar{n},\bar{\bar{d}})$		

(Continued.)

TAB 2 (Continued)

Ground Contribution			Data Location	
	Phase 1		Phase 2	
Code	Sec.	Item	Sec.	Col.
A	23	Apertures		
d			B	44-49
D_1 and D_2	19	Dist. to Face		
	20	A,B,C, or D Width		
h_a	18	Story Ht. (b-d)		
h_u	18	Story Ht. (b-d)		
h_1	18	Story Ht. (b-d)		
H	18	Story Ht. (b-d)		
	20	A,B,C, or D Height		
H_s	19	Setback Ht. (e,j, or o)		
	20	1st Plane Ht. (a,b,c, or d)		
L_p	17	Ext. Wall (a or b)		
L_t	17	Ext. Wall (a or b)		
P	17	Ext. Wall (a and b)		
X_e	23	Ext. Wall		
X_f	22	Floor Weight (a-c)		
X_i	23	Int. Wall		

(Continued)

Ground Contribution

	Phase 1		Data location Phase 2	
Code	Sec.	Item	Sec.	Col.
X_o	22	Ceiling Weight (b-d)		
a	19	Dist. to Face		

Areaways

	Phase 1		Data Location Phase 2	
Code	Sec.	Item	Sec.	Col.
D			B	44-49
XE	23	Ext. Wall (a-d)		
XI	23	Int. Wall (m-p)		
L	17	Ext. Wall (a or b)		
L_a			B	71
P_r	17	Ext. Wall (a and b)		
HB	18	Bsmt. Ht. (b)		
HD (Assumed 3')				
HP1	18	Bsmt. Ht. (b)		
HP2	20	Plane Ht. (a-d)		
HP3	20	Plane Ht. (i-l)		
D1			B	74-75
D2	20	A,B,C, or D Widths		
D3	20	A,B,C, or D Widths		

(Continued)

TAB 2 (Continued)

Interior Partitions

	Phase 1		Phase 2	
Code	Sec.	Item	Sec.	Col.
D			B	44-49
L	17	Ext. Wall (a or b)		
S			B	66-67
X_c			B	58-65
X_p			B	68

NFSS Phase 1 FOSDIC

NATIONAL FALLOUT SHELTER SURVEY

PHASE I

Page no. 0 1

FICTITIOUS BUILDING RTI DURHAM NORTH CAROLINA

Standard location code: 0 0 0 0 0 0 0 0

A D 9 9 0 0 0 0 1 0 1 0

Make no mark in this margin

Make no mark in this margin

(continued)

TAB 3 (Continued)

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Make no mark in this margin

NATIONAL FALLOUT SHELTER SURVEY
PHASE 2

1. PAGE: 0 1

SECTION A

2. NAME AND ADDRESS OF BUILDING OR SPECIAL FACILITY

FICTITIOUS BUILDING RTI DURHAM NORTH CAROLINA

3. STANDARD LOCATION CODE: 0000 0000

4. FIELD OFFICE	5. CONT. NO.	6. FACILITY NO.	7. PART NO.	8. REV. NO.
A D	9 9	0 0 0 0 1	0 1	1

10. CROSS REFERENCE

11. IDENTIFY (OTHER) IF MARKED

(a) (OTHER) CATEGORY OF SPECIAL FACILITY

(b) (OTHER) TUNNEL USE

(c) (OTHER) STORAGE USE

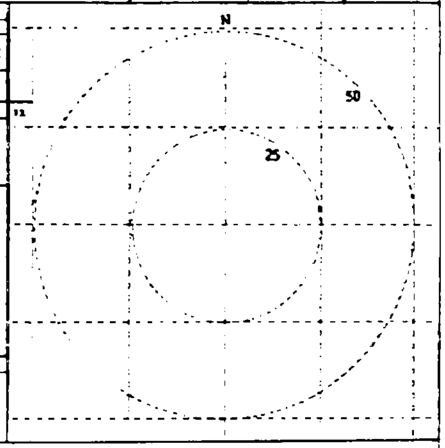
12.

14. REMARKS

SIGNATURE OF ... REPRESENTATIVE AND DATE

SIGNATURE | DATE | SIGNATURE | DATE

13.



SECTION B DATA SUMMARY

0 0	4	0 0 0 7 2 0 0 V		0 0 2 0 8 3 1	X X X X X X	0 7 0 0 4 0	0 4 0 7	X X X X 1 2 1 2 1 2 1 2 0 0 0 0	B 3 0 5 0 5 6	N 0
0 2	2	0 0 2 8 0 0 2 A	X X X X X X X	X X X X X X X	X X X X X X	0 7 0 0 4 0	0 4 0 7	5 5 5 5 1 2 1 2 1 2 1 2 0 0 0 0		N 0

TAB 4 NFSS Phase 2 Data Collection Form

TAB 5

Roof Contribution Calculations
(A&E Guide and Engineering Manual)
(6,400 Sq.ft-No Partitions)

Reduction Factor

Floor Weight	Story No	20 psf Roof EM 80'x80'	20 psf Roof EM 40'x160'	20 psf Roof A&E 6,400 ft^2	30 psf Roof EM 80'x80'	30 psf Roof EM 40'x160'	30 psf Roof A&E 6,400 ft^2	40 psf Roof EM 80'x80'	40 psf Roof EM 40'x160'	40 psf Roof A&E 6,400 ft^2
30	1	.0053	.0044	.0050	.0042	.0035	.0039			
	2	.0140	.0100	.0110	.0092	.0080	.0088			
	3	.0280	.0230	.0270	.0210	.0180	.0210			
	4	.0700	.0640	.0730	.0530	.0480	.0520			
	5	.1900	.1800	.2000	.1400	.1300	.1500			
40	1	.0022	.0018	.0023	.0018	.0015	.0018	.0014	.0012	.0015
	2	.0060	.0054	.0056	.0049	.0043	.0045	.0038	.0035	.0036
	3	.0160	.0150	.0170	.0130	.0120	.0130	.0100	.0092	.0100
	4	.0520	.0480	.0560	.0410	.0370	.0420	.0320	.0300	.0320
	5	.1900	.1800	.2000	.1400	.1300	.1500	.1000	.1000	.1000
60	1	.0004	.0003	.0004	.0003	.0003	.0003	.0003	.0002	.0003
	2	.0016	.0015	.0016	.0013	.0011	.0013	.0010	.0009	.0010
	3	.0066	.0060	.0057	.0053	.0049	.0050	.0042	.0038	.0040
	4	.0320	.0300	.0320	.0250	.0230	.0250	.0180	.0180	.0180
	5	.1900	.1300	.2000	.1400	.1300	.1500	.1000	.1000	.1000
80	1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	2	.0004	.0004	.0004	.0003	.0003	.0003	.0003	.0003	.0003
	3	.0028	.0023	.0027	.0021	.0020	.0021	.0017	.0016	.0017
	4	.0190	.0180	.0180	.0150	.0140	.0150	.0110	.0110	.0120
	5	.1900	.1800	.2000	.1400	.1300	.1500	.1000	.1000	.1000

TAB 6

Roof Contribution Calculations
(A&E Guide and Engineering Manual)
(10,000 Sq.ft-No Partitions)

Reduction Factor

		20 psf Roof			30 psf Roof			40 psf Roof		
Floor Weight	Story No.	EM 100'x100'	EM 50'x200'	A&E 10,000 ft^2	EM 100'x100'	EM 50'x200'	A&E 10,000 ft^2	EM 100'x100'	EM 50'x200'	A&E 10,000 ft^2
30	1	.0060	.0053	.0056	.0044	.0042	.0045			
	2	.0130	.0110	.0130	.0100	.0091	.0100			
	3	.0300	.0270	.0300	.0240	.0210	.0230			
	4	.0750	.0690	.0790	.0550	.0510	.0590			
	5	.2000	.1900	.2000	.1500	.1500	.1500			
40	1	.0024	.0023	.0024	.0019	.0018	.0019	.0016	.0015	.0016
	2	.0065	.0059	.0062	.0051	.0048	.0049	.0041	.0038	.0039
	3	.0180	.0180	.0180	.0140	.0180	.0150	.0100	.0100	.0110
	4	.0550	.0510	.0590	.0410	.0400	.0440	.0330	.0320	.0340
	5	.2000	.1900	.2000	.1500	.1500	1500	.1050	.0890	.1000
60	1	.0004	.0004	.0004	.0003	.0003	.0003	.0003	.0003	.0003
	2	.0017	.0016	.0017	.0013	.0012	.0014	.0011	.0010	.0011
	3	.0069	.0065	.0065	.0053	.0052	.0052	.0043	.0042	.0043
	4	.0330	.0310	.0340	.0250	.0250	.0250	.0190	.0180	.0200
	5	.2000	.1900	.2000	.1500	.1500	.1500	.1000	.0890	.1000
80	1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	2	.0004	.0004	.0004	.0004	.0003	.0004	.0003	.0003	.0003
	3	.0029	.0028	.0028	.0022	.0021	.0022	.0018	.0017	.0018
	4	.0190	.0190	.0200	.0150	.0150	.0150	.0110	.0110	.0120
	5	.2000	.1900	.2000	.1500	.1500	.1500	.1000	.0890	1000

TAB 7

Roof Contribution Calculations
(A&E Guide and Engineering Manual)
(5 Story, 6400 Sq. Ft. Building with Partitions)

			Building 80' x 80' with 30' x 40' core Reduction Factors				Building 40' x 160' with 10' x 120' core Reduction Factors			
			20 psf		30 psf		20 psf		30 psf	
			Partitions		Partitions		Partitions		Partitions	
Roof psf	Floor psf	Floor No.	EM	AE	EM	AE	EM	AE	EM	AE
20	30									
		3	.0210	.0214	.0186	.0193	.0161	.0214	.0137	.0193
		4	.0550	.0580	.0517	.0537	.0413	.0580	.0361	.0537
		5	.1720	.1630	.1670	.1600	.1470	.1630	.1260	.1600
20	60									
		3	.0052	.0053	.0049	.0050	.0042	.0053	.0039	.0050
		4	.0273	.0267	.0258	.0251	.0216	.0267	.0187	.0251
		5	.1720	.1630	.1670	.1600	.1470	.1630	.1260	.1600
30	30									
		3	.0161	.0169	.0146	.0155	.0131	.0169	.0110	.0155
		4	.0442	.0441	.0400	.0408	.0341	.0441	.0274	.0408
		5	.1330	.1260	.1300	.1260	.1030	.1260	.0951	.1260
30	60									
		3	.0043	.0043	.0039	.0041	.0036	.0043	.0031	.0041
		4	.0216	.0208	.0205	.0199	.0163	.0208	.0144	.0199
		5	.1330	.1260	.1300	.1260	.1030	.1260	.0951	.1260

TAB 8

Ground Contribution Calculations*

(A&E Guide and Engineering Manual**)

(Building with 30% Apertures)

Reduction Factor

	80 psf walls		100 psf walls		150 psf walls	
	X_f=30 psf	X_f=50 psf	X_f=30 psf	X_f=50 psf	X_f=30 psf	X_f=50 psf
A&E Guide, 10,000 ft^2 -above sill	.080	.051	.071	.049	.064	.040
A&E Guide, 10,000 ft^2 -below sill	.051	.032	.049	.025	.040	.016
E.M. -100'x100' -at sill level	.039	.032	.032	.026	.024	.019
A&E Guide, 6,400 ft^2 -above sill	.096	.067	.086	.058	.076	.048
A&E Guide, 6,400 ft^2 -below sill	.067	.039	.058	.029	.048	.020
E.M. - 80'x80' -at sill level	.046	.039	.038	.032	.028	.023
A&E Guide, 3,600 ft^2 -above sill	.120	.085	.108	.072	.095	.059
A&E Guide, 3,600 ft^2 -below sill	.085	.049	.072	.037	.059	.024
E.M. -60'x60' -at sill level	.057	.049	.046	.039	.033	.028
A&E Guide, 1,600 ft^2 -above sill	.145	.104	.128	.087	.110	.070
A&E Guide, 1,600 ft^2 -below sill	.104	.063	.087	.047	.070	.029
E.M. - 40'x40' -at sill level	.071	.063	.067	.050	.031	.035

* Ground contribution to third story from infinite planes of contamination.

** Calculations include contributions from lower, adjacent and upper stories.

Areaway Contribution to Unexposed Basement Shelter

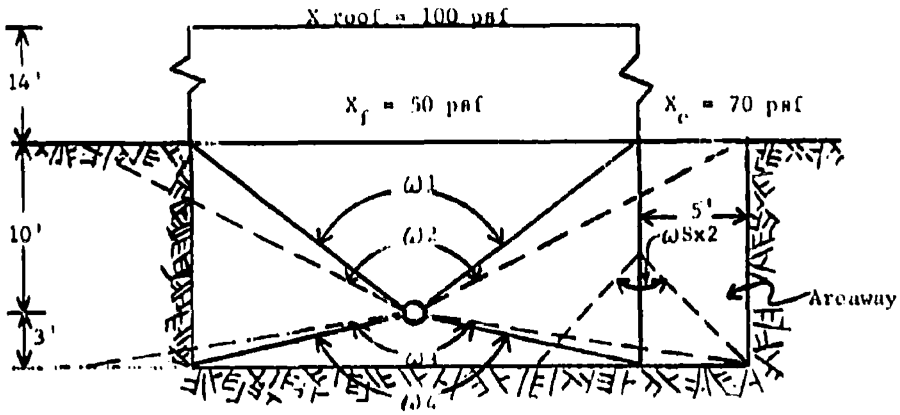
I. TOTAL CONTRIBUTION

The total contribution to a basement shelter as described in Example 5.2 of Reference 5 is 0.0070 (Ground contribution is 0.0014).

II. ADDITIONAL CONTRIBUTION

A. Areaway - No Apertures

If an areaway 5' wide and 50% of the length of the building is added, the calculation of its effect is as follows:



	W	L	Z	ω	G_s	G_a	G_d
ω1	90	110	10	.818	.190	.051	-
ω2	100	120	10	.840	-	.0465	-
ω3	100	120	3	.951	-	-	.251
ω4	90	110	3	.944	.067	-	.282
ωSx2	10	120	6.5	.42	-	-	-

Additional Skyshine $= B_w(XE)\ \left[1-S_w(XE)\right]\left[G_a(\omega 1) - G_a\ (\omega 2)\right]$

$= 0.088\ (0.34)\ (0.0045) = 0.00013$

Additional Direct $= B_w(XE)\ \left[1-S_w(XE)\right]\left[G_d\ (\omega 4) - G_d(\omega 3)\right]$

$= 0.088\ (0.34)\ (0.031) = 0.00088$

Additional Scatter $= B_{ws}(\omega S, XE)\ S_w(XE)\ E\ (e)\left[G_s(\omega 1) + G_s\ (\omega 4)\right]$

$= 0.008\ (0.66)\ (1.41)\ (0.257) = 0.00192$

These contributions must now be multiplied by the perimeter ratio for the areaway or 55/400 in this case.

$$ADOS = \frac{55}{400}\ (0.00013 + 0.00088 + 0.00192) = 0.0004$$

B. Areaway - with Windows

With the upper 1½' of the areaway being windows, the additional contributions are:

Scatter = 0.00192
Skyshine = 0.00486
Direct = 0.00088
0.00766 x 55/400 = 0.0011.

C. Areaway - with Door

Scatter = 0.00185
Skyshine = 0.00013
Direct = 0.00252
0.00450 x 55/400 = 0.0006.

D. Areaway - with Door and Windows

For an areaway with both the upper 1½' apertures and a 3'x7' door, the additional contributions are:

Scatter = 0.00185
Skyshine = 0.00486
Direct = 0.00252
0.00923 x 55/400 = 0.0013.

III. SUMMARY

The reduction factor for Example 5.2 of Reference 5 was 0.0070. The areaway with no apertures increases the overall contribution by approximately 6%. This increase would be approximately 15% if the upper 1½' of the exterior wall adjacent to the areaway were windows. The increase in overall reduction factor would have been about 9% if there had been a 3'x7' door leading into the areaway, and the increase due to the combination of windows and door would be approximately 18%.

Although the overall reduction factors increased only 18%, the ground contribution part of the reduction factor increased by 90% [0.0014 to 0.0027 (0.0014 + 0.0013)]

TAB 10

Tables Representing Data in Engineering Manual Charts

Table		E.M. Chart	Page
1	1, Case 3	Barrier Shielding Effects, Fallout Adjacent to Horizontal Barrier	*
2	1, Case 1	Barrier Shielding Effects, Fallout on Barrier	P - 114
3	2	Wall Barrier Shielding Effects For Various Heights	P - 115
4	4	Roof Contribution	P - 117
5	5	G_s and G_a Directional Responses	P - 119
6	6	G_d Directonal Response	P - 120
7	CF-2	Skyshine Correction	*
8	7	Fraction of Emergent Radiation Scattered in Wall Barrier	P - 121
9	8	Shape Factor for Wall-scattered Radiation	P - 121
10	9	Barrier Reduction Factor For Wall-scattered Radiation For Limited Plane of Contamination	P - 122
11	11 of Ref. 5	Roof Contribution Wall Barrier Effect	P - 124

* Tables 1 and 7 of the present Computer Program are to be retained.

TABLE 2 (Chart 1, Case 1)

Barrier Shielding Effects, Fallout on Barrier

X_o	R_f
0	1
10	.33
20	.20
30	.15
40	.11
50	.082
60	.061
70	.046
80	.035
90	.0262
100	.02
110	.0152
120	.0115
130	.0087
140	.0068
150	.0052
160	.00405
170	.0032
180	.0025
190	.002
200	.00158
210	.00125
220	.001
230	.00079
240	.00064
250	.00052
260	.00042
270	.00034
280	.00028
290	.000227
300	.000189

TABLE 3 (Chart 2)

Wall Barrier Shielding Effects for Various Heights

Height (feet) \ X_e	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
3	1	.76	.60	.50	.38	.31	.25	.185	.15	.12	.094	.076	.06	.05	.04
4	.95	.72	.575	.46	.365	.30	.23	.13	.145	.115	.090	.072	.057	.047	.0383
5	.90	.70	.56	.44	.35	.29	.22	.175	.14	.105	.087	.070	.055	.045	.037
6.3	.84	.68	.53	.41	.335	.28	.20	.17	.135	.100	.083	.065	.053	.043	.036
8	.80	.63	.50	.39	.32	.26	.195	.15	.13	.098	.08	.061	.050	.0405	.034
10	.77	.60	.475	.375	.30	.24	.18	.15	.12	.093	.075	.059	.048	.0385	.0325
12.6	.72	.57	.45	.36	.28	.22	.175	.14	.105	.088	.07	.056	.045	.037	.03
15.9	.68	.54	.42	.34	.265	.20	.17	.13	.10	.081	.064	.052	.041	.035	.028
20	.65	.515	.39	.32	.25	.19	.155	.12	.094	.076	.059	.048	.038	.032	.025
25	.61	.48	.375	.30	.22	.18	.145	.107	.087	.07	.055	.044	.036	.030	.023
32	.575	.45	.35	.265	.198	.165	.13	.098	.079	.062	.050	.039	.034	.027	.020
40	.53	.40	.32	.255	.185	.15	.12	.09	.072	.057	.045	.037	.03	.024	.0185
50	.49	.38	.30	.22	.17	.14	.105	.083	.065	.052	.040	.034	.027	.020	.017
63	.425	.35	.265	.195	.155	.125	.097	.072	.057	.045	.037	.03	.023	.0183	.0155
80	.40	.31	.225	.18	.14	.110	.083	.065	.05	.04	.032	.026	.0198	.016	.013
100	.35	.275	.195	.155	.13	.096	.072	.056	.045	.036	.028	.022	.0175	.0148	.012
126	.32	.240	.180	.145	.11	.08	.061	.05	.039	.032	.023	.0185	.0155	.0125	.010
159	.28	.200	.16	.125	.091	.068	.053	.042	.034	.026	.020	.0165	.013	.0103	.008
200	.24	.180	.14	.100	.075	.057	.045	.035	.028	.021	.017	.014	.011	.0086	.0066
250	.21	.160	.12	.081	.062	.048	.038	.03	.0225	.018	.0145	.0117	.009	.0068	.0055
320	.165	.125	.088	.066	.05	.038	.03	.023	.018	.015	.011	.0088	.0068	.0054	.0042
400	.135	.097	.070	.053	.039	.031	.022	.018	.0145	.0105	.0086	.0067	.0052	.0041	.0035
500	.100	.074	.055	.039	.031	.023	.0175	.014	.01	.008	.005	.005	.0039	.0032	.0025
630	.076	.055	.0385	.03	.021	.017	.0127	.0095	.0073	.0056	.0044	.0036	.0028	.0021	.0017
800	.055	.0375	.028	.0198	.015	.011	.008	.0059	.005	.0038	.0031	.0023	.0018	.0014	.0010
1000	.037	.0260	.018	.014	.0095	.0063	.0052	.004	.0033	.0025	.0019	.0014	.001	.0008	.0007

(continued)

TABLE 3 (Chart 2)

(continued)

Height (feet) \ X_e	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
3	.0335	.0275	.020	.017	.0135	.0107	.0086	.0070	.0056	.0046	.00375	.0031	.0025	.0019	.00165
4	.032	.026	.019	.016	.013	.010	.0082	.0065	.0053	.0044	.0036	.003	.0023	.00185	.00155
5	.030	.024	.0183	.0155	.0125	.0096	.0078	.006	.0051	.0041	.0035	.0028	.0021	.00178	.0015
6.3	.029	.0227	.0178	.015	.0116	.0090	.0072	.0058	.0049	.0039	.0033	.00265	.00198	.0017	.0014
8	.027	.021	.017	.014	.0105	.0084	.0068	.0055	.0046	.0037	.0031	.0024	.00185	.0016	.00135
10	.025	.0195	.0162	.013	.010	.0078	.0063	.0052	.00425	.0035	.0029	.0022	.0018	.00155	.00130
12.6	.023	.0185	.0155	.0125	.0094	.0073	.0059	.0049	.004	.0034	.0027	.0020	.00175	.0015	.00125
15.9	.021	.0175	.014	.011	.0082	.0068	.0056	.0046	.00375	.0031	.0024	.00192	.00165	.0014	.0011
20	.0195	.0163	.013	.010	.0077	.0062	.0052	.0042	.0035	.0028	.0022	.0018	.00157	.00127	.0010
25	.018	.015	.0118	.009	.0072	.0058	.00475	.00385	.0033	.0026	.00203	.00174	.0015	.0012	.00092
32	.0167	.013	.010	.008	.0066	.0054	.0044	.0036	.0029	.0024	.0019	.00157	.0013	.0010	.00081
40	.0155	.012	.0095	.0074	.0059	.0048	.0040	.0033	.0027	.00215	.00175	.00145	.00115	.00092	.00075
50	.0135	.0105	.0080	.0066	.0055	.00455	.00383	.0031	.0025	.00192	.0016	.00125	.0010	.0008	.00068
63	.012	.0095	.0072	.0059	.0049	.004	.0034	.00275	.0022	.00175	.0014	.0011	.00090	.00074	.00060
80	.0103	.0079	.0064	.0052	.0043	.00365	.003	.0024	.00185	.00155	.00125	.00097	.00078	.00062	.00051
100	.009	.0070	.0058	.0046	.0038	.00325	.0027	.0020	.0017	.0013	.0010	.0008	.00068	.00054	.00043
126	.0075	.0060	.005	.004	.0034	.0026	.0022	.00175	.0014	.00107	.00088	.0007	.00056	.00045	.00037
159	.0062	.0052	.0042	.0035	.0028	.00225	.0018	.00148	.00115	.0009	.00070	.00057	.00046	.00038	.00031
200	.0053	.0044	.0036	.003	.0023	.0018	.0015	.00115	.00092	.00073	.00058	.00047	.00038	.00032	.00026
250	.0044	.0036	.003	.0023	.0018	.0015	.0012	.00092	.00075	.00068	.00048	.00038	.00032	.00026	.00021
320	.0035	.0028	.0022	.0018	.0014	.00105	.00088	.0007	.00056	.00045	.00036	.00030	.00024	.00019	.00016
400	.0027	.002	.0017	.0013	.0010	.00082	.00068	.00054	.00042	.00036	.00028	.00022	.00018	.00015	.00012
500	.0019	.0015	.0012	.00093	.00076	.00062	.0005	.00039	.00032	.00025	.0002	.00017	.00014	.00010	.00008
630	.0013	.0010	.0008	.00068	.00053	.00042	.00036	.00028	.00021	.00018	.00015	.00011	.00009	.00007	.00005
800	.00084	.00068	.00055	.00045	.00035	.00029	.00022	.00018	.00015	.00011	.00008	.00007	.00005	.00004	.00003
1000	.00066	.00045	.00035	.00028	.00022	.00017	.00014	.00010	.00008	.00007	.00005	.00004	.00003	.00002	.00002

TABLE 4 (Chart 4)

Reduction Factors for Combined Shielding Effects, Roof Contr. .on

ω \ X_o	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
.001	.00019	.00018	.00016	.00015	.00014	.00012	.00010								
.001259	.00022	.00021	.00019	.00018	.00017	.00014	.00013	.00011							
.001585	.00030	.00029	.00026	.00024	.00020	.00018	.00016	.00014	.00011						
.001995	.00037	.00036	.00034	.00031	.00027	.00024	.0002	.00017	.00015	.00012	.0001				
.002512	.00049	.00047	.00043	.00039	.00035	.00031	.00027	.00021	.00019	.00016	.00014	.00010			
.003162	.0006	.00058	.00055	.00049	.00042	.00039	.00035	.0003	.00024	.0002	.00017	.00015	.00011		
.003981	.00076	.00072	.00063	.00059	.00054	.00047	.00040	.00036	.00032	.00026	.00021	.00018	.00015	.00012	.0001
.005012	.00097	.0009	.0008	.00074	.00066	.00055	.00051	.00043	.00038	.00033	.00028	.00023	.00019	.00016	.00013
.006310	.00125	.0012	.00105	.00097	.00082	.00073	.00062	.00055	.00048	.00039	.00034	.00029	.00023	.00020	.00016
.007943	.0016	.0015	.00135	.00125	.00105	.00095	.0008	.00070	.00059	.00050	.00040	.00037	.00031	.00025	.00020
.01000	.0018	.00175	.0016	.0015	.00137	.0012	.0010	.00088	.00073	.00060	.00051	.00041	.00037	.00031	.00027
.01259	.0023	.0020	.00195	.0018	.00163	.0015	.0013	.00110	.00098	.00077	.00064	.00054	.00044	.00038	.00032
.01585	.00305	.0028	.0025	.0022	.0020	.00175	.0016	.0014	.00125	.00100	.00080	.00069	.00058	.00047	.00039
.01995	.004	.0038	.0033	.0030	.0026	.0022	.00195	.00175	.0015	.0013	.0011	.00087	.00071	.00059	.0005
.02512	.005	.0046	.0040	.0037	.0032	.0029	.0026	.0021	.00185	.0016	.0014	.0011	.00092	.00075	.0006
.03162	.0061	.0057	.0051	.0045	.0040	.0036	.0032	.0027	.0023	.00195	.0017	.00146	.0012	.00094	.0008
.03981	.0075	.0071	.0062	.0058	.0051	.0042	.0039	.0034	.0030	.0025	.0020	.0018	.0015	.0012	.0010
.05012	.0092	.0086	.0078	.0070	.0061	.0054	.0049	.0041	.0037	.0031	.0026	.0022	.0018	.0016	.00125
.06310	.0120	.0105	.0098	.0088	.0080	.0070	.0060	.0052	.0039	.0035	.0033	.0029	.0023	.00185	.0016
.07943	.0150	.014	.0130	.0115	.0100	.0089	.0077	.0068	.0057	.0049	.0040	.0035	.0029	.0024	.0019
.1000	.0190	.0180	.0160	.0146	.0130	.0115	.0100	.0082	.0072	.0060	.0052	.0040	.0035	.0030	.0024
.1259	.0240	.022	.0195	.018	.016	.0148	.01250	.0110	.0090	.0079	.0065	.0054	.0041	.0037	.0030
.1585	.0310	.029	.027	.025	.020	.0180	.01600	.0140	.0120	.0096	.0079	.0065	.0055	.0043	.0037
.1995	.0410	.039	.033	.030	.0275	.0225	.01900	.0175	.0150	.0120	.0095	.0078	.0064	.0054	.0042
.2512	.0525	.050	.046	.042	.0345	.030	.02500	.020	.018	.0155	.0120	.0091	.0075	.0061	.0050
.3162	.070	.062	.060	.057	.047	.036	.03100	.026	.020	.0175	.0148	.0105	.0083	.0071	.0058
.3981	.0920	.0890	.080	.070	.060	.048	.038	.031	.026	.0198	.0165	.0130	.0098	.0078	.0061
.5012	.125	.116	.110	.099	.069	.060	.047	.036	.029	.022	.0178	.014	.0105	.0083	.0066
.6310	.175	.17	.14	.120	.090	.070	.051	.040	.032	.025	.0190	.016	.0110	.0090	.0071
.7943	.290	.27	.19	.145	.10	.080	.055	.045	.035	.027	.020	.0165	.012	.0091	.0074
1.0000	1.0	.40	.22	.15	.12	.081	.06	.046	.037	.028	.022	.017	.013	.0098	.0075

(continued)

TABLE 4 (Chart 4)
(continued)

ω \ X_o	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
.005012	.0001														
.006310	.00014	.0001													
.007943	.00018	.00014	.00011												
.01000	.00021	.00018	.00015	.00012											
.01259	.00026	.00021	.00018	.00015	.00012										
.01585	.00034	.00028	.00022	.00019	.00016	.00012	.0001								
.01995	.00040	.00036	.00029	.00022	.00019	.00016	.00013	.0001							
.02512	.00050	.00040	.00036	.00030	.00024	.00019	.00016	.00013	.0001						
.03162	.0006	.00052	.00041	.00038	.00030	.00023	.00019	.00017	.00014	.0001					
.03981	.0008	.00065	.00054	.00044	.00037	.00031	.00027	.00020	.00017	.00014	.00010				
.05012	.0010	.0008	.00066	.00056	.00044	.00035	.00032	.00025	.00020	.00017	.00014	.00011			
.06310	.0013	.0010	.0008	.00067	.00057	.00045	.00039	.00032	.00027	.00021	.00018	.00015	.00011		
.07943	.0016	.0014	.0010	.0008	.00069	.00054	.00046	.00038	.00033	.00027	.00021	.00018	.00015	.00011	
.1000	.0019	.0016	.00138	.00100	.00081	.00068	.00055	.00045	.00039	.00032	.00026	.00021	.00017	.00015	.00012
.1259	.0023	.0019	.0016	.00135	.00100	.00080	.00064	.00054	.00043	.00037	.00031	.00027	.00020	.00017	.00014
.1585	.0030	.0024	.0019	.0016	.00125	.00099	.0008	.00064	.00054	.00042	.00036	.00031	.00025	.00019	.00017
.1995	.0035	.0029	.0022	.00185	.00133	.00120	.00098	.00075	.00063	.00050	.00040	.00036	.00028	.00023	.00018
.2512	.0040	.0034	.0027	.0020	.00175	.0014	.00101	.00083	.00064	.00056	.00044	.00038	.00031	.00025	.00020
.3162	.0045	.0037	.0031	.0024	.0019	.0016	.0012	.00095	.00076	.00060	.00049	.00039	.00033	.00028	.00021
.3981	.0050	.0040	.0035	.0026	.0020	.0017	.00155	.0010	.0008	.00063	.00052	.00040	.00035	.00029	.00022
.5012	.0055	.0042	.0036	.0029	.0021	.0018	.0014	.0011	.00083	.00067	.00055	.00042	.00036	.00030	.00023
.6310	.0057	.0044	.00365	.0030	.0022	.00182	.0015	.0011	.00086	.00069	.00057	.00042	.00036	.00030	.00023
.7943	.0058	.0046	.0037	.0031	.0023	.00183	.0015	.0011	.00086	.00069	.00057	.00043	.00037	.00031	.00024
1.0000	.006	.0048	.0038	.0032	.0023	.00185	.0016	.001.5	.00088	.0007	.00057	.00045	.00038	.00032	.00025

TABLE 5 (Chart 5)

Directional Responses, Ground Contribution

ω	G_s	G_a	ω	G_s	G_a
.000	.500	.1000	.663	.301	.0727
.025	.495	.0995	.675	.296	.0715
.050	.490	.0990	.688	.290	.0700
.075	.483	.0985	.700	.282	.0687
.100	.478	.0978	.713	.273	.0670
.125	.474	.0972	.725	.268	.0660
.150	.469	.0965	.738	.259	.0640
.175	.463	.0955	.750	.250	.0620
.200	.457	.0948	.760	.244	.0608
.225	.452	.0940	.770	.237	.0594
.250	.448	.0936	.780	.229	.0577
.275	.439	.0932	.790	.220	.0560
.300	.436	.0925	.800	.212	.0543
.325	.429	.0915	.810	.205	.0520
.350	.422	.0906	.820	.195	.0505
.375	.413	.0895	.830	.186	.0485
.400	.409	.0886	.840	.176	.0467
.417	.404	.0882	.850	.166	.0440
.433	.398	.0874	.860	.157	.0420
.450	.392	.0865	.870	.145	.0395
.467	.388	.0855	.880	.135	.0372
.483	.382	.0850	.890	.125	.0345
.500	.377	.0845	.900	.114	.032
.517	.371	.0835	.910	.104	.028
.533	.364	.0826	.920	.093	.025
.550	.358	.0817	.930	.082	.022
.567	.350	.0808	.940	.072	.018
.583	.343	.0797	.950	.060	.015
.600	.335	.0785	.960	.049	.012
.613	.327	.0075	.970	.037	.009
.625	.323	.0765	.980	.025	.006
.638	.318	.0754	.990	.012	.003
.650	.310	.0745	1.000	0	0

TABLE 6 (Chart 6)

Directional Response for Various Heights

Height (feet) \ ω	0	.1	.2	.3	.4	.5	.6	.7	.8	.9	.92	.94	.96	.98	1.0
3	.90	.88	.85	.82	.78	.749	.705	.645	.55	.40	.36	.30	.22	.10	0
4	.892	.872	.842	.81	.77	735	.69	.63	.535	.37	.32	.26	.175	.06	0
5	886	864	.833	.802	764	.724	.675	.615	.505	.34	.29	.23	.15	.05	0
6 3	.881	.86	830	.795	752	.71	.662	.595	.48	.31	.26	.19	.11	.05	0
8	.876	.855	.825	.78	74	.697	.65	.572	.455	.28	.22	.15	.10	.04	0
10	.871	.85	82	.775	.730	.680	.63	.551	.438	.25	.20	.14	.085	.04	0
12.6	.868	.845	.806	.76	.713	.665	61	.525	.41	.22	.16	.12	.075	.03	0
15.9	.865	.84	.800	.75	.703	.65	.59	.50	.38	.20	.15	.10	.06	.02	0
20	.862	.83	.788	.736	.69	.635	.565	.48	.35	.175	.13	.09	.05	.01	0
25	.861	825	.775	.725	.673	.615	55	.45	.32	.15	.10	.07	.04	.008	0
32	.858	.817	.76	.71	.655	.595	.52	.425	.29	.124	.09	.05	.012	.007	0
40	.855	.81	.75	.695	.635	.574	.498	.398	.255	10	.07	.04	.009	.006	0
50	.854	.80	.736	.68	.613	.549	.465	.35	.220	.08	.05	.03	.01	.005	0
63	.852	.795	.725	.658	.594	.52	.44	.325	.195	.06	.042	.025	.01	.005	0
80	.851	.780	.71	.64	.563	.492	.40	.297	.15	.047	.035	.024	.01	.005	0
100	.850	.775	.69	.62	.54	.46	.37	.26	.12	.04	.03	.02	.01	.005	0
126	.840	.76	.67	.59	.505	.425	.335	.225	.10	.035	.027	.019	.01	.005	0
159	.830	74	.65	.56	.474	.392	.30	.180	.082	.030	.024	.019	.01	.005	0
200	.825	.735	.635	.532	.445	.362	.26	.155	.075	.026	.022	.018	.01	.005	0
250	.820	722	.615	.510	.420	.327	.23	.140	.070	.026	.022	.018	.01	.005	0

TABLE 8 (Chart 7)

Fraction of Emergent Radiation Scattered in Wall Barrier

X_e	S_w
0	.0
10	.22
20	.35
30	.46
40	.53
50	.585
60	.63
70	.665
80	.695
90	.72
100	.74
110	.755
120	.775
130	.78
140	.795
150	.805
160	.82
170	.83
180	.84
190	.845
200	.85
210	.86
220	.87
230	.88
240	.885

TABLE 9 (Chart 8)

Shape Factor for Wall-scattered Radiation

e	E
.1	1.094
.2	1.176
.3	1.246
.4	1.300
.5	1.340
.6	1.369
.7	1.391
.8	1.406
.9	1.411
1.0	1.414

TABLE 10 (Chart 9)

Barrier Reduction Factors for Wall-scattered Radiation for Limited Strip of Contamination

ω \ X_e	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140
.00000															
.01000	.003	.0004													
.01259	.004	.0005	.0002												
.01585	.0042	.0010	.00037	.00019											
.01995	.005	.0016	.00058	.00031	.00019										
.02512	.006	.0021	.0010	.00040	.00027	.00019									
.03162	.009	.0037	.0015	.00071	.00040	.00025	.00019								
.03981	.011	.0051	.0020	.00110	.00067	.00040	.00029	.00019							
.05012	.015	.0065	.0035	.0015	.00099	.00067	.00041	.00030	.0002						
.06310	.020	.0096	.0048	.0020	.00175	.00100	.00072	.00044	.00033	.00022	.00018				
.07943	.025	.0130	.0079	.0042	.0025	.00150	.00110	.00081	.00059	.00040	.00036	.0002			
.1000	.039	.0170	.0100	.0067	.0041	.0030	.0019	.0014	.00083	.00072	.00051	.00036	.00027	.00019	
.1259	.049	[illegible]	.0150	.0100	.0070	.0044	.0034	.0022	.00170	.0011	.00069	.00068	.00049	.00037	.00027
.1585	.064	.038	.022	.015	.0105	.0048	.0038	.0040	.0030	.0020	.0015	.0010	.00087	.00064	.00050
.1995	.081	.053	.037	.026	.0175	.0125	.0092	.0062	.0049	.0037	.0028	.0019	.0016	.0012	.00084
.2512	.120	.076	.052	.035	.029	.020	.0149	.011	.0083	.0061	.0049	.0038	.0029	.0019	.00165
.3162	.200	.138	.090	.050	.042	.034	.025	.019	.015	.0115	.009	.0070	.0055	.0041	.0035
.3981	.40	.200	.145	.105	.036	.065	.053	.040	.033	.025	.0185	.0148	.0118	.0096	.0078
.425	.52	.28	.175	.130	.10	.084	.060	.05	.0395	.032	.024	.018	.014	.0115	.0096
.4500	.65	.36	.23	.160	.12	.100	.065	.067	.054	.040	.035	.025	.0190	.0150	.0125
.460	.69	.40	.27	.185	.145	.110	.097	.079	.06	.048	.039	.030	.02	.0172	.014
.470	.73	.45	.31	.21	.165	.135	.102	.092	.072	.059	.045	.037	.027	.0195	.016
.480	.77	.50	.35	.25	.19	.15	.125	.10	.085	.070	.055	.041	.035	.025	.019
.490	.82	.56	.42	.30	.24	.185	.150	.13	.100	.085	.070	.055	.041	.039	.025
.5000	1.00	.75	.60	.45	.35	.310	.25	.185	.150	.120	.094	.076	.060	.050	.0400

(continued)

TABLE 10 (Chart 9)

(continued)

$\omega \backslash X_c$	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290
.1995	.00069	.00054	.0004	.00031	.00023	.00019									
.2512	.0013	.0098	.00077	.00061	.00046	.00037	.00029	.00021	.00019						
.3162	.0027	.0022	.0016	.00125	.0010	.00077	.00061	.00050	.00038	.00030	.00024	.0002			
.3981	.0059	.0046	.0037	.0030	.0022	.00130	.00150	.00110	.00089	.00074	.0006	.00048	.00038	.00032	.00027
.425	.008	.006	.005	.0035	.003	.0024	.0019	.0015	.0012	.00093	.00075	.00053	.0005	.00038	.00033
.4500	.0100	.0089	.007	.0057	.0042	.0036	.0028	.0020	.0017	.0014	.0011	.00084	.00070	.00058	.00043
.460	.012	.0099	.0082	.0065	.0052	.0040	.0033	.0025	.0019	.0016	.0013	.001	.0008	.00068	.00053
.470	.014	.0115	.010	.008	.006	.0050	.0039	.0030	.0025	.0019	.0015	.0012	.00098	.0008	.00064
.480	.0155	.014	.0115	.0099	.008	.0060	.0048	.0039	.0031	.0024	.0018	.0015	.0011	.00098	.0008
.490	.020	.016	.015	.012	.010	.0080	.0060	.0050	.0040	.0033	.0025	.0018	.0015	.0012	.001
.5000	.0335	.0275	.020	.0170	.0135	.0107	.0086	.0070	.0056	.0046	.00375	.0031	.0025	.0019	.00165

TABLE 11 (Chart 11)

Roof Contribution Wall Barrier Effect

X_i	R_f
0	1.000
10	.670
20	.480
30	.350
40	.264
50	.200
60	.153
70	.118
80	.089
90	.0695
100	.0550
110	.0430
120	.0332
130	.0262
140	.0207
150	.0162
160	.0129
170	.0101
180	.0080
190	.0064
200	.0051
210	.0039
220	.0031
230	.0025
240	.00196
250	.00159
260	.00125
270	.00101
280	.00082
290	.00066
300	.00053

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(AE Phases 1 and 2, RTI FOSDIC with and without partitions, and Engineering Manual), and analyses of individual building input and procedural differences judged to have affected the PF differences (I); construction details of four buildings used in comparing experimental and calculated PF's (J); trapped potable water field data gathered in the 33 building survey (K); detailed analyses of "Technical Operations Research" reports that affect the procedures used to calculate PF's (L-N); a summary of conclusions and recommendations made by "Technical Operations Research" and concurred with by RTI (O); and detailed recommended modifications to the NBS-NFSS Computer Program (P).

CIVIL DEFENSE, NATIONAL FALLOUT SHELTER SURVEY (ERROR ANALYSIS, SAMPLE SURVEYS), RADIATION SHIELDING LITERATURE ANALYSIS, STRUCTURAL CHARACTERISTICS, PROTECTION FACTOR COMPUTATIONS (COMPUTER AND MANUAL), TRAPPED POTABLE WATER.

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THE RESEARCH TRIANGLE INSTITUTE, Durham, N. C.
OCD Sub-task 1115A - Final Report R-OU-81, Part II
Analysis of Survey Data. Edward L. Hill *et al.*
15 February 1964 (UNCLASSIFIED) 4 pp. plus 16 appendices.

This part contains sixteen appendices (A-P) to the chapters of Part I of the final report for OCD Sub-task 1115A, Analysis of Survey Data. These appendices contain details of computer programs used in categorization of structures with respect to technical shielding characteristics and resultant tabulations (A-E); details of the RTI 33 NFSS Phase 1 building sample selection (F); an illustration of procedures used in identifying building elements critical to PF computations (G); RTI computational method and forms used in making Engineering Manual PF calculations for the 33 sample buildings (H); descriptions of the 33 buildings, the five PF results

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